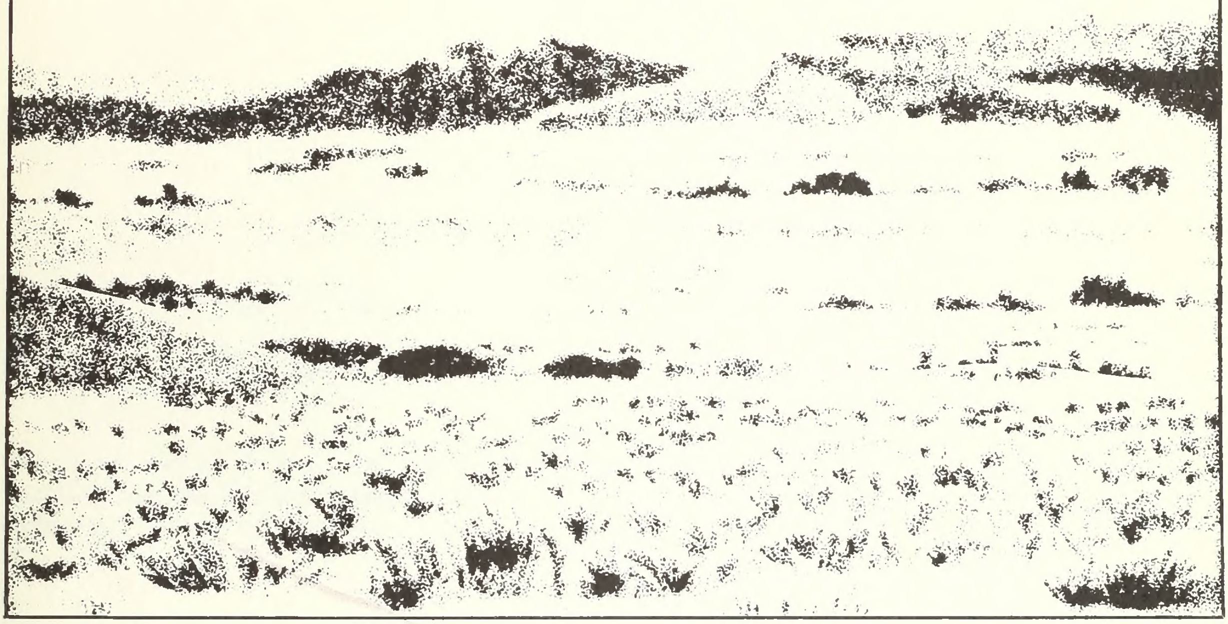
Developing Strategies for Rangeland Management



A Report Prepared by the

Committee on Developing Strategies for Rangeland Management

Board on Agriculture and Renewable Resources
Commission on Natural Resources
National Research Council

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PREFACE

The Federal Land Policy and Management Act of 1976 (FLPMA) established procedures for the development and protection of all lands in the public domain. Approximately 70 million ha (174 million acres) of such lands in the western United States are managed by the Bureau of Land Management (BLM) under the principles of multiple use and sustained yield. BLM is required by FLPMA to make an inventory of the resources of these lands and to prepare comprehensive land use plans consistent with the management goals set forth in the act. In addition, BLM is required by the National Environmental Policy Act of 1969 to prepare environmental impact statements for major actions affecting the environment. The Bureau is now preparing these statements within their grazing management program.

The planning process undertaken by BLM to fulfill the legislative mandates of FLPMA has raised a number of issues concerning management of public rangeland. These issues interest a wide range of people, including the users and managers of the public rangeland; managers of intermingled lands owned privately and by the states; other federal agencies; state and local officials; conservation and environmental groups; and the academic community in the physical, biological, economic, and social sciences.

The Bureau of Land Management asked the National Research Council (NRC) to examine scientific and methodological issues that arise from the Bureau's stewardship role. In response to the request, the NRC formed the Committee on Developing Strategies for Rangeland Management under the auspices of the Board on Agriculture and Renewable Resources of the Commission on Natural Resources. The committee in turn organized a series of six workshops during a 2-year period to discuss rangeland management issues. The workshops examined (1) forage allocation (Workshop I, November 17-18, 1980); (2) inventory of rangeland resources (Workshop II, December 8-9, 1980); (3) impacts of grazing intensity and specialized grazing systems on the use and value of rangeland (Workshop III, March 16-17, 1981); (4) effects of range management on plant communities (Workshop

IV, April 7-8, 1981); (5) application of socioeconomic techniques to range management decision making (Workshop V, May 11-12, 1981); and (6) political and legal aspects of range management (Workshop VI, September 14-15, 1981).

Each workshop provided a forum in which the participants could address issues selected by the committee. The committee asked scientists and other experts to review a given topic or to present a critique of a paper presented at the workshop. The presentation of each paper was followed by general discussion. These workshop papers, along with transcripts of the general discussions, are available for examination in the Archives of the National Academy of Sciences, and copies of them can be obtained for appropriate charges (for reproduction, handling, and postage) through the Academy archivist.

Upon completion of each workshop, the committee reviewed the proceedings, and indidvidual committee members were asked to prepare a summary. The summaries include recommendations related to the issues focused upon at the workshops. This volume, which presents summaries of the first five workshops, was reviewed by the committee chairman and by certain committee members selected by him. It was also reviewed at the board and commission levels, but not by the entire Committee on Developing Strategies for Rangeland Management.

Unexpected changes in funding caused premature termination of the study, and the committee was unable to complete its planned integration of the numerous issues raised by the workshops. Nevertheless, it is hoped that the information and analysis presented here will make a contribution to the study of rangeland ecosystems and the management of these valuable public resources.

INTRODUCTION

The public rangeland of the United States is a complex and diverse resource of great significance, particularly to the western half of this country. Like all natural resources, rangeland is perceived and valued differently by the various segments of our society, and, inevitably, these valuations lead to conflict over land use. Rangeland can fulfill a variety of wants and needs, but a major use has been and continues to be livestock grazing. In fact, since about 1850 the current ecological status of western arid and semiarid rangeland has largely been shaped by interactions of grazing and intermittent drought.

As custodian and manager of the public rangeland, the Bureau of Land Management (BLM) is subjected to pressures from all classes of users and must respond by developing and implementing appropriate management strategies, some of which may involve sharp departures from past practices. The chapters in this volume highlight issues of a scientific nature that were raised in the NRC workshops and appear to the committee as critical to the Bureau in facing its management tasks.

Chapter 1 addresses forage allocation. How resources are allocated has always been controversial in natural resource management, and, accordingly, forage allocation has become controversial as well. A great deal of misunderstanding exists, not only among livestock growers, but also among other users and in the academic community, about the current theory and practice of forage allocation. Forage allocation is designed to be a process whereby objective scientific analyses of relevant data can be systematically brought to bear on resource use decisions. Essentially, the process entails the compartmentalization of a range ecosystem and subsequent manipulation of its primary components in such a way that the management goal for that particular ecosystem can be most effectively achieved. Chapter 1 focuses on physical and biological aspects of forage allocation and on methodologies available for determining and displaying various allocation schemes. Questions raised include the following: What criteria are used in making allocation decisions? What are the allowable levels of use at different places and during

different seasons? What characteristics are exhibited by different animals that are relevant to selecting grazing sites? What are animal plant preferences by species and season? What is the level of efficiency by which vegetation is converted to animal products? How can a specific site be best protected from wind and water erosion? How can these various considerations be systematically integrated and implemented?

The inventory of rangeland resources and the monitoring of range condition are discussed in chapter 2. The customary purpose of an inventory is to determine methodically such characteristics as the type, amount, and location of various resources. While there has not been much disagreement over the particular techniques used in the rangeland inventory process, a good deal of debate has centered on basic needs for data and the appropriate level of accuracy and precision necessary to support responsible management of the rangeland resource. Originally, much of the inventory data collected by BLM was to be used to support analysis of stocking rates for grazing animals and to make decisions about altering those rates. Subsequently, the emphasis shifted away from that application of the inventory (and away from an inventory program altogether) to determination of stocking rates through monitoring studies with periodic adjustments over time. While the ultimate use of data in the decision-making process will always depend on the problems that require solving, any agency should have a consistent base line of information providing critical details about the resources it is managing. Chapter 2 analyzes the scientific basis and criteria for a rangeland inventory and monitoring program in BLM. Some specific questions addressed include the following: What has been the nature of BLM's inventory problems in the past? What are the basic differences between inventory and monitoring? What are the data needs of BLM in its management role? What levels of staffing and planning are necessary to implement and administer an inventory and monitoring program? How should an inventory and monitoring program be designed? What are the constraints to adequate sampling and measurement? Which inventory and monitoring techniques are best suited to BLM's needs? How can the quality of data collection be ensured? How should inventory data be interpreted?

Different management strategies and treatments have been used to improve the vegetative component of rangeland for all uses (e.g., livestock, watersheds, wildlife, and aesthetics). Chapters 3 and 4 discuss various aspects of the issues raised by these strategies and treatments. Chapter 3 describes the concepts and principles of grazing systems and significant impacts that grazing intensity and specialized grazing systems can have on vegetation, watersheds, wetlands and riparian habitats, composition and productivity of fauna, and domestic livestock. Common grazing systems include deferred and rotational grazing, which alter the seasonal distribution of livestock on the range and thus vary the periods of use and nonuse of the vegetation. Local and regional environmental variations have often confounded researchers in their assessment of the success or failure of particular grazing systems. Chapter 4

deals with range improvements that directly affect the vegetative resource and alter the composition of plant communities in various desirable ways, depending upon management goals for the area. This chapter explores effects of range management practices on the ecology of plant communities in the West. The analysis begins with an assessment of the evolution and ecology of various range plants and communities. The discussion then moves into successional patterns and productivity potentials of the major range ecosystems in the West, such as the sagebrush and salt desert regions, the pinyon-juniper ecosystem, and the shrub-steppe and desert shrub areas in the hot, arid portions of the Southwest. The role that range improvement practices play in the overall goals of multiple use and sustained yield on public rangeland is also analyzed.

Economic and social issues relevant to range management decision making are assessed in chapter 5. Several socioeconomic analytical techniques have been applied to problems encountered in managing public rangeland. Some specific questions treated include the following: What is the role of economic analysis in public rangeland management? What are the criteria for investment feasibility and project selection on public ranges? How can the economic impact of agency programs on users and local communities be measured? What techniques are available for the valuation of nonmarket outputs? What sociological techniques, such as social impact assessments, are available for evaluating effects of range management decisions on individuals and local communities? Finally, under what conditions should negative impacts be mitigated and what means are available for doing so?

The issues inherent in the management of public rangeland are complex. Although this volume could not present a complete synthesis of our current understanding of these issues, it is our hope that these abbreviated summaries will spur further useful debate and investigation.

Chapter 1

FORAGE ALLOCATION

INTRODUCTION

This chapter focuses on the physical and biological aspects of forage allocation, including the large domestic and wild herbivores and the plants on which they graze. Recent legislation, including the Federal Land Policy and Management Act of 1976 and the Public Rangelands Improvement Act of 1978, has broadened the concept of forage allocation considerably. To meet the legislated mandates of multiple use and sustained yield, BLM can no longer consider grazing alone. Today, livestock and other grazing animals represent only a portion of the many users of the rangeland resources in the West.

This chapter has four major sections. The first introduces the forage allocation problem and discusses its human dimensions. The second is concerned with the physical site, the plants that grow there, and the animals that use the plants. The third presents an overview of analytical approaches to forage allocation and discusses some special sampling and analytical problems. The fourth details the committee's conclusions and recommendations.

HUMAN DIMENSIONS OF THE PROBLEM

Burch (1980) argues that many allocative mechanisms exist, in addition to scientific expertise, and examines the nature and limits of social tradition, markets, politics, and adaptation to ecological variation as alternative allocation mechanisms. There are a variety of trends in these allocation mechanisms. Trends in social tradition suggest the need for alternative property institutions for range resources. Trends in markets suggest fewer and larger farms, domination by large corporations, and real limits to growth, which will be unheeded by the market until there is a crash. Trends in politics suggest an emerging constituency whose amenity values directly challenge past range management philosophies and practices. Scientific expertise is merely the most recent means for allocating range resources, and it is in the early stages of development--theoretically, methodologically, and empirically.

Rangeland invokes widely different images for different persons across the country. Interestingly, public rangeland supplies only a small amount of the national demand for meat, but an extremely large amount of the national demand for myths of free-ranging rugged

individualists. Certainly, significant elements of the fashion, entertainment, and tobacco industries would be greatly diminished without the image of the western stockman. It is evident that public rangeland may be far better at producing the stuff of myth and national identity than economically prudent beef and mutton products. Yet, in the long run, the production and perpetuation of national myth may be one of the most valuable resources harvested from public rangeland.

McConnen's (1980) critique of Burch's paper points out that although Burch rightly reminds us of the complexity of the range system, he has no allocative concepts to substitute for market allocation, competitive allocation, and carrying capacity. The implication is that many biological analyses are ritualistic in that they attempt to force certainty upon an uncertain world. In these analyses, sub-optimization is used as a substitute for holistic investigations. Changing patterns of public rangeland use have involved losses, especially to ranchers. The scientists understand the issues of efficiency, but they have little to contribute to loss allocation, which is the main problem. McConnen predicts more court cases brought by ranchers who can demonstrate economic loss because publicly owned wildlife, which the rancher cannot control, graze his private land for parts of the year. Thus there will be increasing public-private land interactions. The criterion for "best" land use may be different for public than for private rangeland, and future objectives for public rangeland will include nongrazing uses.

INFLUENCES OF PHYSICAL SITE, PLANTS, AND ANIMALS

Gifford (1980) reviews hydrological problems on grazing lands. Some 100 studies of rainfall simulator experiments pertinent to rangeland are summarized. He identifies the determinants of the infiltration rate of water on rangeland: type of soil, plant cover, range condition, and the percent slope. Although cover in semiarid plant communities is difficult to define, it is important in vegetation allocation. There is little evidence of the importance of one plant species over another in terms of site protection per unit weight. Some workers, however, have found faster infiltration around fibrous-rooted plants than around those with taproots. Generally, each plant-soil combination has a characteristic infiltration pattern that changes with successional stages or condition classes of the community, even though the soil type does not change. Infiltration improves with improved range condition, although infiltration rates on a given site exhibit both spatial and temporal variability. These rates are sensitive to land management because it influences the soil surface. Factors that affect water erosion of rangeland have been investigated, but nearly all investigations of wind erosion have been derived in other situations. Probably 50-60 percent cover is sufficient to maximize infiltration and minimize erosion. Further, there is no evidence that cover requirements for either infiltration or erosion should vary with the type of grazing livestock or wildlife.

Caldwell's (1980) paper on plant requirements for prudent grazing focuses on the carbon balance in forage plants and their physiology. Progress in understanding plant requirements has been achieved from clipping, grazing, and morphological investigations. More qualitative than quantitative information has been provided from these investigations.

Caldwell discusses proper use and allowable use factors in forage allocation. The proper use factor is the percentage of an individual forage species that can be utilized when the range as a whole is properly managed, while the allowable use factor measures the percentage of the shoot system of a particular species that can be removed and still permit recovery. Although these factors are useful guidelines, the tabulated values create an impression of more precision than is warranted. There is no apparent objective basis for deriving tables of proper use factor values. Different listings of proper use factors, issued from time to time, have varied as much as 25 percent, and there are subjective evaluations for certain sites and circumstances. Allowable use factors are obtained from clipping isolated plants and thus are subject to complications of the release from competition.

Lewis (1980) reviews the papers by Gifford and Caldwell. He indicates that although great progress has been made in understanding the dynamics of hydrological processes, most simulation models of these phenomena have been carefully tuned for specific locations without spatial heterogeneity in site factors. Although there may be relatively large differences in infiltration rates between different locations, actual runoff differences from pastures under different treatments in the same location may be quite small. One must consider not only infiltration but also differences in the evaporation and transpiration from the soil and plants under different treatments to look at the total water balance. Lewis calls for a focus on the relationships among erosion rates, geological and accelerated erosion, and soil formation rates.

In his discussion of Caldwell's paper, Lewis points out that herbage yield, determined from a single measurement, is far less than actual total shoot production of the vegetation in the field. The greater the diversity of the site, the greater the diversity of the vegetation, the longer the growing season, and the greater the consumption by unmanaged herbivores, the greater will be the difference between standing crop and production. In most grazing lands about two thirds of the net primary production is unconsumed. Of that consumed, the amount consumed by insects or other small organisms may be much greater than that consumed by livestock. This point is extremely important to forage allocation in defining allowable use. Lewis emphasizes the point that perhaps we can manage on the basis of overall range condition and bypass many of the allocation decisions. High range condition usually provides high plant species diversity and results in vegetation that will support multiple uses. Generally, the goal should be good or excellent range condition.

Skiles (1980) discusses abiotic and biotic factors that influence site preferences of grazing animals. Temperature, water availability, wind, topography, soil type, and other abiotic factors are considered. Quantity of forage, intraspecific behavior, and interspecific interactions and management are among the biotic factors considered. Skiles compares several different indices of dietary preference using the same data set. The indices generally require knowing the actual or percentage weight of a forage plant in a diet relative to the same variables in the available herbage. The utility of these indices in forage allocation is considered. Comparisons are made for cattle, sheep, bison, and pronghorn antelope with diet categories of grasses, forbs, and shrubs. Since the values for preference obtained in one study determined by one methodology may not agree with the values in another study, Skiles (1980) recommends that preference determination be standardized.

Skiles next reviews literature on dietary botanical composition of large herbivores. Some 137 scientific papers and articles on dietary botanical composition of cattle, sheep, mule deer, white-tailed deer, elk, bighorn sheep, pronghorn antelope, horses, burros, and bison for the United States and Canada were considered. These studies show that although cattle are primarily grass eaters, forbs can sometimes account for half of their diet. In desert-shrub ranges, cattle eat shrubs. Depending on the season and pasture treatment, domestic sheep consume roughly equal amounts of forbs and grass. Mule deer eat mostly shrubs, but in some studies it has been shown that grass or forbs may make up more than half of their diet. Elk are highly varied in their dietary habits, bighorn sheep seem to prefer grasses over forbs and shrubs, and pronghorn antelope frequently prefer shrubs. Horses consume primarily grass, but burros apparently eat whatever plants are in bloom or in season. Bison are grass eaters. Skiles provides a detailed analysis of literature data with respect to the photosynthetic pathway, C_3 or C_4 in the diets of large herbivores. The fact that animals prefer green, growing plants to dry, mature plants is of importance in any particular season because of the differential responses in C_3 and C_4 plants to environmental conditions.

Moen (1980) provides a detailed and methodologial evaluation of animal growth and biomass, ecological metabolism, metabolic efficiencies, forage intake, and population requirements as they relate to carrying capacity. Because impacts on animals are based on a power of body weight, growth curves are needed for all age classes of free-ranging wild and domestic animals, from birth to death, including annual cyclical influences. Maximum weights of grazing ruminants are usually reached near the end of the plants' growing season and minimum weights in late winter or early spring, depending on weather and snow conditions and reproductive demands. Ecological metabolism, which is the energy cost of all basic physiological processes for free-ranging animals, varies because of maintenance, activity, and production costs, which change as a result of seasonal patterns and growth, reproductive functions, activity patterns, weather and thermal exchange, and other biological functions.

Ecological metabolism can be expressed as a ratio of ecological metabolism per day to base-line metabolism, and this ratio is called a multiple of base-line metabolism. Expected values of this ratio range from 1.5 to 4 for free-ranging ruminants over an annual cycle. The basal level, of course, can be calculated as a power function of body weight. Expressing ecological metabolism as a multiple of base-line metabolism is useful in calculating forage intake of free-ranging animals. In order to obtain gross energy digested, calculations would proceed from net energy for maintenance, activity, and production through the steps of heat increment, energy lost in urine, and energy lost in feces and methane.

In his discussion of Skiles's paper, Wallace (1980) notes that he is not aware of any research that demonstrates that grazing animals select for various nutrients. There is clear evidence that an animal's diet on a particular range varies with the animal that grazed the range previously, reflecting the availability of forage more than animal-to-animal interactions. Preference by the animal and palatability of the forage do not seem to be prerequisites for animal performance. Wallace criticized Moen's use of NRC information on pen-fed domestic animals for wild and even for domestic animals on rangeland (NRC 1966, 1975, 1976). Moen's implications are that grazing animals change the quantity or the quality of their diet to maintain production, but that domestic animals often do not maintain production. For example, in a drought, conception rate decreases, calving interval increases, and yearling animal gains decrease. There is some conflict in the literature with respect to forage intake and stage of pregnancy of female ruminants. Intake may decrease during the last trimester simply because of the lack of capacity for both an expanded rumen and an expanded uterus. In many cases on rangeland when forage digestibility decreases the animal cannot compensate by eating more because the ingested material does not move through the intestinal tract fast enough.

ANALYTICAL APPROACHES TO THE PROBLEM

Van Dyne and Kortopates (1980) summarize the optimization models for management of grazing lands and develop more complex models and apply them to a common data set. Forage allocation involves consideration of two or more groups of plants and two or more large herbivores on the range. The herbivores prefer different plants in different seasons, and the plants have different allowable uses. The problem is to select the optimal combination of herbivores to maximize use of the vegetation and yet not abuse the plants or the site. They illustrate the problem for two-species situations graphically and numerically, using both linear and nonlinear programming optimization models. They show the impact of varying objective functions and contraints in the problem formulation. They illustrate how to incorporate risk, uncertainty, and differential weighting because in practice the input parameters are not known with certainty. The models that are formulated and solved with the use of

either hypothetical or real-life data vary from linear, single-season, deterministic models to more realistic and more complex models that are nonlinear, multiple-season, weighted-objective function, and the deterministic equivalent of stochastic models with chance constraints. The six main models are applied to common data for comparison, wherein four animal species were available, the plants were aggregated into five ecological groups, and the year was subdivided into four unequal seasons. Stochasticity in these models arises from chance constraints that reflect uncertainty in the random variables entering the model. Information required in the general model formulation includes the hectares of grazing land and allowable use factors, beginning standing crop of vegetation plus growth increment, and vegetation loss due to natural causes other than grazing for each plant species or group. Furthermore, the number of days in each season, the total forage intake requirement of the different animal species per day by season, and the relative dietary preference values are needed. The solution indicates the numbers of different animal species to be grazed in different seasons. They contrast the use of mathematical programming optimization problems to simulation models for determining forage allocation. They conclude that it is currently impractical to use simulation models extensively in determining forage allocation. Further, they compare the limiting factor method, the proper use factor method, and the optimization method of forage allocation for the same situation. The optimization method allows a selection of combinations of large herbivores and results in a higher total of animal units of stocking than would normally be considered by either the limiting factor or the proper use factor method. They discuss the role of proper use factors to derive diet information in contrast to deriving it from preference information. They show with hypothetical calculations that if everything is known with certainty, one may use the proper use factor to obtain a diet composition if the range composition is known. Their formulation of successively more complex models is methodical and detailed and should serve as a guide for potential users of this approach in renewable resource management.

Examination of the results of 12 different model structures presented by Van Dyne and Kortopates leads them to conclude that there is no optimal answer in forage allocation and that the strength of the mathematical modeling approach is to provide an easy way to obtain alternatives rather than a single answer. The manager should question the validity of the data entering the analysis, and perhaps even the form of the model, by making more than one calculation. Through analysis, not only could suboptimal combinations be derived but the most heavily used and most limiting plant groups could be determined. Display of not only the single best combination of herbivores, but also the top three or more combinations of herbivores, ranked from the optimal down to lower degrees of efficiency in utilizing as much of the available herbage as possible, represents the most useful and practical function of optimization models.

Hanson (1980) examines the Van Dyne and Kortopates paper. First, he notes that the solution of an optimization model may not be global and that the solution needs to be placed in the hands of wise and knowledgeable managers who can make the final decision rather than blindly following a model prescription. Second, he notes that the model needs to be tractable, the solution feasible, and the concept realistic and communicable.

Good estimates of values for allowable use factors, loss rates of vegetation, and diets of animals do not currently exist in many situations. These components are linear proportionalities in the model and severely affect the solution. In the usual formulation, utilization and loss factors are either time-dependent constants or random variables, but in reality they are functions of environmental and physical properties. More information is needed on these relationships. Hanson believes that preference is the least estimable component of the forage allocation model. He illustrates the simple ratio for preference used by Van Dyne and Kortopates and also notes that Skiles (1980) discusses five other formulations. These empirical formulations are lacking, and an index for preference needs to be developed in a mechanistic manner from animal ethology. In the simplified formulations presented by Van Dyne and Kortopates, certain constraints make it impossible to increase herbivore numbers from season to season. Thus further developments of the model must include expressions of reproductive capability for animals. In the shortgrass prairie example data set examined by Van Dyne and Kortopates, their stochastic formulation predicted about 20 ha (49 acres) per animal, which is close to the long-time average stocking rate for cattle of about 21 ha (52 acres) per animal from experimental field data. However, the deterministic models suggested stocking rates much higher than those that had been observed in the field. Hanson believes that the model structure is versatile and with limited knowledge of the various components the linear deterministic form can be used. With more information and understanding the model can be adapted to the nonlinear, stochastic, weighted formulations. The present models are only a steppingstone for more complex models where the optimality function might be to maximize nutrient intake by herbivores and subsequently lead to maximizing red meat production in contrast to the present approach of maximizing vegetation use only. Finally, Hanson shows how optimization models could be coupled to total-system simulation models to help the manager obtain a picture of the ecosystem and aid in wise and knowledgeable land use.

Holechek et al. (1980) review methods for determining the botanical composition, similarity, and overlap of large herbivore diets on rangeland. Various methods for determining diet composition include direct observation of the animal, plant utilization measurement, stomach analysis, fecal analysis, and esophageal and ruminal fistula sampling. They illustrate the advantages of these methodologies with examples from the literature. Samples from feces and fistula forage seem to be the best. However, in both cases one must develop methodology in the laboratory to determine the botanical

composition of the samples. Even though the plant species or genera or group level can be identified by microscopic examination, the species in the feces may not be proportional to those consumed because of differential digestibility and recognizability. In several studies the composition of grasses and shrubs in the feces was significantly higher than in the diet, whereas the converse was the case for forbs. Furthermore, fewer species often are found in the feces than in the fistula forage samples. This has also been found when one artifically formulates diets from different plant materials, submits them to microdigestion in vitro or in vivo, and then uses microhistology to estimate diet composition. The problem can be ameliorated by using regression equations to correct estimated percent weight to actual percent weight. The procedure suggested is to collect sufficient plant material of important species or groups in the diets so that formulated mixtures can be made and digested in vitro. Regression equations can then be used to account for the differential digestion bias in the feces. It is important to note that the feces show a diet over more than one day, whereas a sample from a fistula represents diet for a period of usually less than one hour. Considering this and the fact that frequently fewer species are found in feces than in utilization or esophageal sampling leads one to question the ability of the observers to ascertain the diets. Thus it may be necessary to correct for differential digestibility and recognizability of species in the feces.

Overall, one must select the best method of field sampling and the best method of laboratory analysis. In the studies reviewed by Holechek and his colleagues the combination of esophageal fistulated animals in the field to collect the sample and microhistological analysis in the laboratory was the best. However, some of their work suggests that plant identification problems in the laboratory are fewer with a microscopic point technique than with microhistological analysis. Fecal sampling in the field, with microhistological analysis in the laboratory, gave the most precise results because an essentially unlimited number of samples can be collected unless the animal under study is particularly rare. However, the literature previously reviewed showed that the fecal analysis is more of a qualitative than a quantitative procedure. In terms of time and cost, direct observation of untamed animals ranks first because virtually no equipment except binoculars and little preparation are required. But this technique ranks low in accuracy. Therefore all methods are either inaccurate, expensive, time-consuming, or lacking in precision or possess some combination of these factors. More research evaluating the accuracy of fecal analysis is needed because it is simple and can be applied to a variety of wild and domestic populations at various densities on the rangeland. Although several procedures are available for evaluation of dietary similarity and overlap, the results of such analyses are not useful in making forage allocation decisions. It is the diet composition per se that should be utilized in quantitative decision making rather than the overlap information described in an index.

Jensen (1980) reviews the methods BLM has been using in making forage allocation decisions for several decades. The methods include, but are not limited to, the weight-estimate-based approach, an ocular-reconnaissance approach, a limiting factor approach, mathematical programming approaches with primary emphasis on linear programming and network analysis applications, and a simulation modeling approach. In the weight-estimate method, after the production (or more precisely the peak standing crop) of each plant species is determined it is multiplied by a proper use factor for each animal species using the management unit and a total allowable use factor for each plant species. This results in the amount of grazeable forage that may be allocated to each grazing animal and the maximum amount of each plant species production that is to be allocated to all grazing animals. In the ocular-reconnaissance method, density (more precisely cover) is determined by estimating how much of the ground is covered by the current year's growth of all vegetation. This is subdivided into the different plant species. A proper use factor is applied, based on each animal species using the unit. Thus percent composition of the plant species times the proper use factor is multiplied by the percent density to give a forage acre factor that is then multiplied by surface acres to arrive at forage acres. Forage acres are divided by a forage acre requirement to determine the animal unit months (AUMs) available for each kind of animal using the area.

The limiting factor method is discussed in detail with due consideration to the general rationale of utilizing plant use factors; calculating grazeable forage, diet preference, and consumption; determining available AUMs; and partitioning AUMs to livestock and game. The partitioning of the AUMs to the different large herbivores is done in a step-wise manner. Thus managers must decide on the priority order of the different herbivores in allocating the forage. In practice, they have not been dealing with individual plant species but aggregating the production by plant class and then applying dietary preference for each kind of herbivore to the plant class rather than the species. Jensen stresses that vegetation inventories are a method to arrive at an initial stocking rate, independent of the method used to convert vegetation inventory data into AUMs of the different animal species, and the inventories must be followed up with utilization, trend, and actual use studies, and suitable adjustments made.

Nelson (1980) focuses on modeling methods for investigating large herbivore competition. Greater efficiency of forage resource utilization through common-use grazing increases the likelihood of interspecific competition problems. Competition may be disturbance competition, which occurs when an individual of one species leaves the vicinity of an individual or group of another species. Little is known about the social conditions needed to bring about such an interaction. Elk, however, assume a definite subordinate position to cattle throughout most of their distributional range. One must be careful, however, to determine whether it is the presence of the animal or the prior use of forage that results in disturbance

competition. Also, one must be careful to indicate the specific areas of the range involved, such as in the case of mule deer and cattle. Mule deer tend to inhabit areas with rough topography and cattle areas with gentle topography when in the same pasture, allotment, or region. Part of the disturbance competition between sheep and other animals is related to the fact that the sheep may be present in large numbers in a range band. Dogs, horses, and man also complicate matters. Most competition is over food, but it is not a simple interaction. Nelson proposes a series of complex formulary models to evaluate exploitation among large herbivores. This requires determining a marginal substitution rate by which one animal species may be substituted for another in a grazing system. These substitution rates are defined in symbols from classical competition model literature, particularly the Lotka-Volterra equations, and by linear trade-off lines for two-animal-species grazing systems. A delta factor is calculated as the probability of an individual animal species being unable to eat a forage item as the animal encounters it, either because that plant species is not a preferred forage item or because of prior utilization of that species by other animals. Nelson suggests that this delta factor is closely related to daily gains of animals. He suggests that his models account for diet similarity, consumption rate, availability, utilization, and number of animals. They do not account for animal distribution, height of reach, and timing of grazing. Nelson is in the process of testing his formulary models against the output of computer-simulated, multiple-animal-species grazing systems. His formulary models have not been verified in the field and have been only partially verified through this computer simulation. Competition technology is still in its infancy, and thorough research into the nature of large herbivore exploitation has only recently begun.

Cooperrider and Bailey (1980) describe a computer simulation model that has been developed to predict impact on ungulates of selective forage removal by free-ranging big game and domestic animals. After briefly reviewing studies of animal and plant population dynamics and models of animal nutrition, and ecosystems, they derive criteria for forage allocation simulation. Such a model should be realistic, should consider forage quality variations, should deal with components of animal populations rather than the total population, could include information on foraging as expressed in dietary preferences, should consider weather, should be quantitative rather than qualitative, should use data that are available from standard inventories, and should be useable by managers in field offices possessing computer terminals. Finally, the models should be unbiased and legally defensible.

The models they develop depend strongly on data and require habitat, population, weather, and basic biological data. The first three of these are site specific. The biological data are more universal relationships that govern flows among state variables. The model requires information on the number of plants per acre, the average weight per plant at each phenological stage, and the major plant species within each stratum or habitat type on each allotment.

It also requires information on seasonal use of habitat by individual species. The percentage of each major plant species in the diet of each ungulate in each season is also necessary input. As initial conditions, the number of ungulates of each sex and age class of each ungulate species must be known. Weather records are used to drive the model, and these include records of snow depths as well as records of temperature and precipitation. The model operates on 2-week intervals. It is expressed in a series of difference or reoccurrence equations coded in FORTRAN when it is operating on a computer. In effect, the model is driven with records of forage production by phenological state. Forage removal is influenced by the animal's choice of habitat, choice of forage, and animal size. There is feedback on forage production within a year, but not between years. As plants are grazed, they become less available to produce forage in that given year, but not in future years. Management is included in the model through movements of domestic livestock and through hunter harvest. Hunter harvest is simulated as if it occurs all at one point in time.

The model is being developed and run with data collected from a BLM district in which food habit and habitat use information has been detailed for four species of wild ungulates and two species of domestic livestock. Since the data are still being analyzed, many of the processes and parameters of the model still need refinement. To illustrate preliminary results for a simulation showing on a 2-week basis the annual cycle of standing crop of forage (based on input information) and the forage availability and nutritional value, results for numbers of ungulates on a yearly interval are presented, with the numbers of wild ungulates varying as a function of stocking rates of domestic animals.

Forage allocation to one or more competing ungulate species is a complex biological problem, and the simulation approach allows a great deal of realism to be incorporated into a model of the biological system. It will not, however, produce directly a solution or optimal allocation for an area. Solutions for forage allocation problems will always depend on goals. The simulation approach can be used to determine if and how goals can be achieved.

Martinson (1980) describes a linear programming model for forage allocation that BLM has implemented within the last 2 years. This model draws upon information from the soil-vegetation inventory analyses (SVIM) of BLM as well as other data that must be drawn from files, the literature, or guesswork. Inputs required for this model include forage intake rates for the different animal species, seasons of use, proper use factors, dietary estimates, annual plant production, allowable use factors, and grazing suitability. Forage intake rate data are taken from literature reviews. Season of use is determined by the field offices for the specific situations. Proper use factors are taken from agency tabulations, which are derived largely from judgmental estimates. These are used as diet surrogate information when actual dietary estimates are not available. Dietary estimates may be, in some cases, taken from fecal analysis or scientific literature. Annual plant production data are estimated

from the inventories in specific locations. Allowable use factors are taken from agency listings, which again are based largely on estimates. Grazing suitability is entered as a percentage figure for each animal species for each specific land unit. Generally, the above data are entered at the level of the site write-up area (SWA) from the vegetation inventory. Thus there may be several hundred spatial units in the analysis.

A linear programming model (see those examples developed by Van Dyne and Kortopates (1980)) is used as the structure of the problem. Effectively, the model seeks to maximize the amount of forage available for grazing subject to several constraints. Constraints restrict the overuse of each plant (as based on the allowable use factor), prevent the exceeding of the proper use factor, and ensure meeting the measured, estimated, or adjusted dietary composition considerations. This is done by calculating relative preference values, which can be assigned, calculated from proper use factors, or derived from literature values. The decision maker can use a dietary range factor, which subjectively estimates the diet composition. Lower and upper bounds of animal numbers also can be entered as constraints. The linear programming model is solved by a network reformulation of the problem. Commercially developed and system-dependent software is used. The network algorithm is operated through a user-interactive program. The program may be accessed by users in field offices over remote terminals. Examples of several runs are partially illustrated. Present developments at BLM include broadening the problem to a multiple-objective linear programming approach to allocation. The inclusion of flow equations to connect the separate grazing seasons and the evaluation of different preference indices to improve dietary estimates are also being considered.

Innis (1980) reviews and critiques the preceding five papers. He begins with a philosophical treatment of the definition of a model, model utility, and the nonscientific nature of models. He notes that the Holechek et al. (1980) paper covers the assigned field well in compiling and condensing information and ideas. Nevertheless, innovative approaches are not suggested or developed. More consideration should be given to the following question: "What do we want the dietary information for?" It is possible that some of the crude techniques provide information that is accurate enough for our purposes.

With respect to Jensen's (1980) paper, Innis focuses on the definitions of some of the variables, with a special emphasis on the allowable use factor. The paper is based on a static philosophy; i.e., such items as use factors do not change but remain the same over time. It is questionable whether the results made from comparing the limiting factor method with other methods could detect whether there was any statistically significant difference.

Innis had considerable difficulty understanding Nelson's (1980) paper, particularly because only preliminary results were available at the time. Basically, the approach is one of simulation, and emphasis is based on concepts rather than on data. Several

components of the model have not been measured in the field or laboratory, or may not be measurable at all. Yet Nelson is comfortable in including these components in the model. Model construction in most cases includes a combination of bias (derived from expert opinion) and data. The weakness in Nelson's model is that it has been largely untested and there may be some internal inconsistencies.

Innis was hard pressed to examine the details of the Cooperrider and Bailey (1980) model, since it is unclear whether or not forage is an internal variable (i.e., a state variable) or an external variable (i.e., a driving variable). Innis believes that objectives should specify data needs. Building a model based on available data only may not reach the objectives of the manager. Therefore the careful consideration of objectives, field inventory data, and model structure and function are required. It may be impossible or impractical to obtain certain data needed to construct or validate some components of simulation models.

Innis expresses considerable concern over the methods Martinson (1980) used in calculating diets. The propensities for the model users to adjust the diet subjectively until it resembles their expectations make the approach an unrealistic one. Innis notes that there is a real need for more precise and commonly understood definitions for the main variables. This is particularly important in an interdisciplinary environment. One of Innis's overall conclusions is that "the challenge today isn't in building models, but in interpreting them."

CONCLUSIONS AND RECOMMENDATIONS

Defensible forage allocation is restricted by imprecise measurement and definitions, scattered research efforts, and poor transfer of information from scientist to manager.

Information Needs in the Political and Social Sciences

The forage allocation problem centers on how much vegetation is consumed by various classes of grazing animals. However, only livestock numbers can be reasonably manipulated. Does this mean for example, that deer numbers are to be left unmanaged and changes in allocation taken from or added to livestock as wildlife numbers wax and wane? Or is that whole problem ignored and allocations simply set by an inflexible formula? Who should decide how many deer are enough on a given grazing allotment, and what are the allocation criteria? If manipulation of numbers of some grazing animals is difficult, how are "desired" allocations to be accomplished? These are questions of significant practical importance in the implementation of any allocation policy. In resolving these questions, the demands of the new constituency concerned with range

amenity values should not override the utilitarian needs of local ranchers and communities. At the same time, however, alternatives should be explored such that the exercise of private rights to common property also ensures responsible land use.

Management decisions will continue to be made in the social, political, and economic environment, but the resource capability should provide meaningful criteria for land use and forage allocation decisions. Thus land managers need the nerve to risk failure, to not simply respond to the demands of markets but to identify the real social and ecological limits to what the range can produce.

Biophysical Information Needs

Data Needs

Soil. Soil erosion on semiarid lands occurs at a higher natural rate than on forest lands. Part of this is geologic erosion and is unrelated to the actions of man. An understanding of the differences between geologic and accelerated erosion is essential if the effects of management practices are to be realistically assessed. We recommend that means of differentiating geologic from accelerated erosion on rangeland be given greater emphasis than in the past and that subsequent research be focused on individual or groups of range sites.

The success of site protection in preventing accelerated erosion should be evaluated on bench mark areas. It will be either impossible or prohibitively expensive to prevent geologic erosion. The factors affecting wind and water erosion should be identified and if possible quantified. While we have a good understanding of the factors that influence water infiltration, we need a better understanding of the linkage between infiltration rates and basin runoff.

Hydrology. Information available on site requirements for watershed protection that is based on vegetation is inconsistent, incomplete, and contradictory. Research indicates at least 50 percent plant cover is required to maintain soil surface stability for the kinds of "research" storms imposed as treatments. For arid and semiarid rangeland this is impossibly high under any circumstances. Therefore little serious attention need be given to allocating vegetation separately for watershed protection except perhaps in very specialized situations where watershed protection is an overriding issue.

Vegetation-soil-storm relationships are not understood well enough at this time to provide recommendations on forage allocation for watershed protection.

Plants. The seasonal distribution of aboveground net primary plant production, in vitro digestibility, and nitrogen content needs to be identified by major species, minor plant groups, and plant part

for average years, with knowledge of how these characteristics vary under different environmental patterns. A distinction should be made between aboveground standing crop and aboveground net primary production.

It is unclear what proportion of the plant's primary production needs to be allocated for its own survival. Arbitrary assignment of average proper use factors by plant species is hardly defensible because there are so many exceptions and variations. Nevertheless, most agree that too much defoliation by whatever means is harmful to the individual plant.

Quantitative use factors currently being employed by BLM should be critically reviewed to determine the basis for these values. If clipping studies served as the ultimate data source, the reliability of this information should be assessed by determining how well the clipping studies met three criteria: (1) Were these studies conducted with plants in a realistic competitive environment? (2) Are the parameters of productivity and vigor assessed indicative of productive potential and competitive position in the community? (3) Does defoliation effected by clipping correspond reasonably well to approximate patterns and timing of defoliation of individual plants by grazing animals? If one or more of these criteria are not met, the basis for the proper use factors should be used with great caution.

Although there exists a reasonable understanding of plant response to defoliation and how sensitivity varies with growth stage and among species, BLM should recognize the paucity of quantitative information available to determine proper use factors and allowable use factors. Thus we recommend more scientific research in this area, and encourage BLM to support such research if it meets its needs.

Animals. Differential site selection by animals affects species preference because of forage availability. Site selection is probably due to a number of factors, singularly and in combination, such as range site, community type, landform features, and availability of water. Presence of human activity as well as other animal activity may also contribute to the dispersal pattern of animals. We recommend that greater attention be paid to site selection of animals.

Animal preference has been mathematically described in a qualitative way but is probably not accurate in predicting a diet. This problem needs to be worked out in a more mechanistic manner to include the behavior of the animal involved. Only if a better formulation of preference can be made should it be used in optimization modeling.

One area of data collection that needs special attention is food habits. Much BLM effort and manpower have been spent designing and implementing a system for measuring vegetation (forage). By contrast, little effort has been expended to develop methods for measuring food habits. Yet food habit data are as important to forage allocation decisions as are forage production data.

The differences among kinds and levels of competition for vegetation need to be better delineated. There are many animal species involved. A pound of vegetation allocated to a deer is not necessarily a pound taken away from any other potential consumer. At least part of that pound was not useable by others.

Overall. Until the data pool becomes large enough to provide reliable numbers for computer input, a reasoned opinion may be more appropriate for many difficult management choices. A precise number with insufficient or inadequate formulation is probably worse than an informed guess. The data we do have should provide the managers and other decision makers with a background against which expert opinions are judged. When a proper use factor of 50 percent is given for a certain plant species, it can only be judged wrong if there is more research inferring it to be incorrect than supporting it.

Most resource-management decisions are based on soft data. (Many decisions in business, the military, and academia are also.) Given the vast areas being managed by BLM with limited funding, BLM will always be working with limited and inadequate data. For the BLM manager, the problem is how to most efficiently collect the most important data, how to synthesize these data into meaningful predictions, and how to do both within budgetary limitations.

The contradictory results concerning site requirements appear to be due to differences in range sites. If site requirements are established in relation to a particular range site or a group of range sites, then it would be likely that similiar results would consistently occur. We recommend that site requirement data and information be identified with respective range site(s) because this kind of information is site specific.

Evaluating current forage allocation models will be difficult because there are few, if any, areas where reliable data have been collected over several years and can be used to verify model predictions. BLM should select a few diverse areas on which to test and demonstrate procedures and forage allocation models. Data necessary for implementing forage allocation models and testing predictions for forage, livestock, and wildlife should be collected. Establishing the accuracy of BLM procedures and models on a few intensively studied areas would provide needed credibility for the court contests that appear certain to occur.

Many of the public lands managed by BLM are poorly understood with respect to spatial and temporal variabilities in runoff and erosion potentials, production potentials, and long-term stability and the relationship of stability to a wide variety of uses (e.g., grazing, mining, and recreation). It would appear logical therefore for BLM to solicit funds for necessary monitoring programs as well as for an active program in both applied and basic research on management-related problems. The notion that management decisions should be based on an acceptable long-term information base must be incorporated into the system.

A long-term research program, even if only modestly funded, needs to be established by BLM to address quantitative questions of plant response to grazing in semiarid and arid rangeland environments.

This research is needed not only to resolve quantitative use factors but also to address questions such as how plant use should be adjusted during periods of drought.

Methodology Needs

Almost as many animal preference measures are being developed and used as there are workers studying preference. A standardized preference measure with a standardized interpretation of the preference values produced by that measure is needed. Standardizing procedures would bring a modicum of order to this seeming chaos and preclude further confusion by subsequent studies.

A need exists for improving fecal analysis and for developing and testing models used in synthesizing field data. Although the accuracy of fecal analysis for estimating food habits has been questioned for several years, all aspects of fecal analysis can be subjected to scientific inquiry. Fecal analysis is the only currently available technique that can economically provide the food-habit information needed by BLM. If fecal analysis is to be widely used, further research and development of the technique should have high priority.

The needs of the Bureau would be served best by having a sound classification system that would include a range site classification combining significant soil and climatic variation and an assessment of current vegetation and soil condition by the major range sites in each administrative unit. The current vegetation should be assessed as to its ecological status and its value for specific use(s). The vegetation should be reevaluated periodically to determine whether the direction of change is toward the goals of management.

There is currently considerable debate among range management professionals concerning the application of the range condition and trend concept. Technically, range condition is defined as the current state of health of a specific piece of rangeland and reflects the combined effects of past and present use, climate, soil, and vegetation. Trend is the direction of change of range condition. Originally, the climax state was considered the ideal or excellent condition, and the degree of deviation (stages) from climax indicated progressively poorer health.

It is implicit that climax is the desired management goal on all ranges. But climax is attainable only when there is no use, or very conservative use, by domestic livestock, so there is no appreciable alteration of the climax condition. To manage for a less than excellent range condition appears incomprehensible, but it is in reality often the desired management goal. This apparent contradiction is not widely appreciated or understood and has resulted in much confusion concerning the value of the range condition concept.

Where objectives of management and the desirability of climax coincide, such as in the case of native perennial grasslands, there is no conflict between the range condition classes and range

management. Where woody species, shrubs and trees, make up a greater proportion of the climax vegetation, the relationship between management objective(s) and the range condition concept often weakens. Because of this inconsistency between the range condition and management goals, the relationship between the two should be reevaluated. Greater clarification and understanding of the range condition concept and its application to management goals are needed.

It becomes increasingly important for us to be able to fully allocate the range resources for various uses. The more accurate the knowledge of the allocation, the more fully the resources can be used without detrimental effects on the productivity of the ecosystem. The allocation process seeks the maximum levels of use without impairment. The resources need not be utilized at the maximum level at any time, but it is important that we know what that level of use is. For present as well as future allocations, there is a great need for a general purpose allocation model that is capable of coping with changing demands and uses of range resources. We recommend that continued efforts be made to develop realistic, general models that include potential uses of range resources. Developing models for each region (or subregion) is more realistic than developing a single complex model for BLM's entire domain. Reliable sampling of rangeland on the large areas administered by the Bureau with the few people available is impossible. The best approach is probably to develop simulation models for each administrative unit, calibrated on bench mark areas. A major objective in developing a simulation model has been to incorporate much that is known of the biology of wild ungulates into allocation decisions. This knowledge, particularly the impacts of weather, habitat, season, and forage preferences and qualities, has been neglected in forage allocation by government. Simulation models are more flexible in using this knowledge than are optimization models. Although simulation models will not <u>directly</u> produce optimal solutions to allocation, they should be regarded as complementary to optimization models.

There is also a definite need for further development of optimization models. They eventually should include all main uses of the ecosystem, to the extent that comparable output can be defined. They should be nonlinear and should incorporate spatial variation, temporal variation, and animal grazing distribution, and they should incorporate stochastic variation in such a way that reasonable confidence levels can be maintained. Possibly this can be done by using simulation output for optimization input. Obviously, the models and methods for producing the data described above cannot be developed in time for the environmental impact statements. However, progress on these methods should be sought.

The greatest weakness of the optimization model now in use (Martinson 1980) is its lack of seasonal variations. Seasonal variations in the diet and distribution of animals are often large and critical to the well-being of animals and forage resources. It is conceptually possible to incorporate seasonal patterns in linear programming, and this should be a high priority for the BLM optimization model.

Two optimization formulations were presented to distribute forage among classes of animals to minimize the forage left at the end of a season. For either model to be applicable, the results must be realistic. Thus the number of animals in optimal combinations should not be allowed to vary beyond what is managerially feasible. Also, in choosing an optimization model, BLM should be encouraged not to select a formulation that unduly biases against any particular type of animal.

The variety of vegetation allocation models available to BLM are currently useful, however, only as conceptions. They probably do not even qualify as a best guess. The reason is the lack of site-specific information. A best guess of stocking rates should come from the experience of grazing an area for several years. This, combined with adequate monitoring and preliminary modeling, should allow for adjustments during 5- to 10-year periods.

If we develop complex simulation and optimization models, there is some danger of slavish reliance on them. Models must be viewed simply as tools for the scientist who is the decision maker.

Organization and Operations

Research information, inadequate though it may be, may be inaccessible to BLM. We recommend that BLM develop contracts with appropriate research organizations to review and synthesize research information on specific topics.

A team structure for management within BLM would be desirable. The use of both internal and external advisory groups would also be desirable. However, the final decision maker on forage allocation problems must be a professional range ecosystem manager by virtue of training and experience. The current procedures of elevating a staff member to the position of decision maker regardless of educational training and of making decisions on the basis of adversary management between staff members and political action groups must be changed. Key personnel will need to obtain degrees in range ecosystem management and training in the use of advanced decision-making tools. Considerable emphasis must be placed on keeping up with new developments in ecosystem management through workshops, training sessions, educational leaves, involvement in professional society activities, and so forth. Rewards in the Bureau should be geared to recognize such involvement. A strong professionalism and *esprit de corps* should be developed in the Bureau, undergirded by a justified feeling of pride in being an employee of the agency.

The importance of the public lands and the Bureau's need for additional manpower and money should be communicated to Congress. If increased funds and increased manpower were made available immediately, it is unlikely that the Bureau would be able to use them wisely. However, with adequate planning and development, large increases in manpower and funding would pay dividends in the wise management of the public lands.

To managers of natural resources, the most important discovery of this century is our growing awareness of the complexity and diversity of natural ecosystems. The most carefully conceived forage allocation decisions, based on the most carefully conceived study of local conditions, will always be first approximations--our best guesses of how we should manage resources and of how the resources (and the public) will respond to our treatments. Each land management plan should address how results will be monitored, predictions tested, and treatments adjusted to account for the unexpected responses of resources (and the public). A continuous monitoring of this sort is needed in BLM.

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Chapter 2

INVENTORY OF RANGELAND RESOURCES

INTRODUCTION

As steward of 174 million acres (70 million ha) of rangeland, the Bureau of Land Management (BLM) conducts inventories of basic resources. Through the years, considerable disagreement has developed about the conduct of range inventories and the use of the inventory to manage rangeland and, particularly, livestock grazing practices.

The purpose of the NRC committee in conducting this workshop was to establish the basis and criteria for rangeland inventories and monitoring and to suggest solutions to the BLM's inventory problems. We will not list rights and wrongs for the BLM inventory, nor give detailed instructions for change. That would require more knowledge of the Bureau's organization and its use of inventory and monitoring information than we have. Instead, we will provide information, concepts, and principles that should help the Bureau to decide where and how changes should be made in its organization and procedures. Much of this analysis is in the form of papers, commissioned for the workshop, discussing important aspects of range inventory and monitoring. In some cases, authors have gone beyond summary reviews to make recommendations to the Bureau about inventory and monitoring procedures.

In addition, this chapter emphasizes points made in the workshop papers or in the discussions that followed their presentation. We also draw conclusions from the papers and discussion and make a number of observations and recommendations concerning relevant Bureau operations and organization. Frequently, we pose questions for the Bureau with the hope that a serious attempt to answer them may lead the Bureau to some solutions.

REVIEW OF BUREAU INVENTORY PROCEDURES

Through its Soil-Vegetation Inventory Method (SVIM) the Bureau collects, in a uniform, systematic way, data for several Bureau needs, including unit resource analysis, management framework plans (MFPs), activity plans, and environmental assessments. SVIM is designed for use with BLM's Integrated Habitat Inventory and

Classification System. Although SVIM does not inventory all renewable resources, it provides a framework for their inventory and includes as well wildlife, recreational, and aesthetic values. Thus SVIM is part of an integrated inventory system.

Since BLM began using SVIM, there has been much criticism of its range inventory program--most of it aimed at the SVIM. The complaints are, generally, that (1) SVIM is too detailed, (2) BLM tries to collect too much information with it, and (3) too many grazing decisions are based on a single SVIM inventory. Using the range inventory to determine grazing capacity and set stocking rates has caused the most controversy. An analysis of the criticism has led the committee to conclude that BLM's problems with its range inventory arise not primarily from the SVIM procedure itself, but from a host of other factors, including the way SVIM has been promoted, implemented, and used. Although SVIM is not without faults, they are secondary and caused perhaps by more basic problems. The committee believes that the SVIM described in the Bureau's manual is basically sound. Moreover, the several methods used in SVIM for collecting soil and vegetation information are generally appropriate to their intended use and have been widely accepted by range science (Risser 1981).

INVENTORY VERSUS MONITORING

During the past year, the political environment has put BLM under pressure to curtail its range inventory. Some critics have advocated eliminating the SVIM inventory in favor of monitoring. The Bureau is sensitive to this pressure and has been studying a possible shift from inventory to monitoring for many of its data. In planning for this shift, BLM has conducted or sponsored a number of monitoring studies (DOI 1980a, 1981). On April 10, 1981, a first draft of a "Rangeland Monitoring Study Procedures Manual" was distributed for comment and recommendations.

In general, the committee agrees that BLM should develop a monitoring program. But to discard the range inventory would be irresponsible. Instead, BLM should consider its entire need for data for the range management program (see the section on "Inventory and Monitoring Needs" below) and decide how best to meet it. Some combination of an inventory with successive monitoring events might satisfy more efficiently and effectively the Bureau's needs for data and meet its management objectives at the same time. Important considerations to meet in designing this combination are that it be pragmatic, logical, achievable with available resources, and scientifically sound.

The committee is disappointed with the Bureau's recent venture into monitoring of range conditions. BLM's efforts to date (DOI 1981) do not convey the right sense of priorities. The report just cited emphasized inventory use and methodology and even who would do the monitoring (Sharpe 1980). But more fundamental questions relating to basic objectives were treated lightly or omitted

completely. An exhaustive list of monitoring methods should follow determination of what is to be monitored and why (Risser 1980). The Bureau needs to be more specific than merely to say that it will monitor for "actual use, utilization, trend and climate" (DOI 1981). Monitoring implies the repeated measurement or observation of an ecosystem characteristic to detect change and record events (Pieper 1980). The Bureau must decide what events or changes in status need to be monitored and how quickly they must be detected. Then it must identify those attributes of various components (e.g., vegetation, soil, and litter) that are sensitive to influences inducing change (Ogden 1980, Pearson and Thomas 1980). Only then will it be appropriate to consider the location of monitoring sites and specific methods.

The one-time inventory should be modified to gather information of a permanent nature and should include mapping of soils, range sites, current vegetation patterns (seral stages), and physical features and planimetric control now mapped under SVIM. The Bureau should consider reducing the vegetation inventory of SVIM to characterization of plant communities only, using the stable attributes of ground cover and density of perennials. Forage production data, which are costly to obtain, might be limited primarily to areas where forage allocation is a problem, instead of being collected for all lands (see the section on "Interpretation of Inventory" below). We do not recommend that BLM abandon the work it is doing on forage allocation. However, the Bureau tried to move into this area before the technology was sound and without the data needed to give forage allocation a fair chance. BLM should continue its work on forage allocation, but at a more moderate pace and only where there are better chances of success.

The implication of our suggestions is that determination of herbage yield should be deemphasized in the range inventory. This is tantamount to saying that BLM should no longer rely on the inventory production data as the sole basis for determining grazing capacity or stocking rates. If BLM accepts this, it needs to plan alternative procedures for making decisions when production data are not available (see the subsection on "Initial Grazing Capacity" below).

The delineation and mapping of range sites would be by far the most important activity of a revised range inventory. It was stressed in this and the other workshops--especially Workshops III and IV--that BLM must place more emphasis on range sites. By the same token, range science research must relate findings more to site (i.e., by range sites or habitat types) to increase the application of research among all range users.

Assuming that monitoring will play an increasingly important role in BLM, the Bureau should be able to make an easy transition to monitoring where range inventories have been completed. For these areas, range sites have been mapped and base lines for monitoring are available. However, where inventories have not been conducted or planned, BLM needs to develop alternatives for stratification of

the landscape as a basis for monitoring. Unless monitoring is site-specific, it will lose much of its utility.

ANALYSIS OF BUREAU INVENTORY PROBLEMS

Inventory and Monitoring Needs

Because the Bureau has been using data from inventories for a long time, it seems unnecessary to suggest that the Bureau identify its data needs. Nevertheless, in view of the controversy over the BLM inventory process, much of it relating to the kinds and amounts of data collected, it seems prudent for the Bureau to make an exhaustive analysis of its data needs. Thus the committee felt it was important to include a paper on data needs (Artz 1980).

Artz describes in general terms the scope of BLM needs. He identifies laws that require data and points out who uses the data. BLM should carry the analysis into specific requirements of laws and users. By users we mean those who share the rangeland resources--forage, timber, wildlife, water, minerals, recreation, and aesthetics--and hold values concerning them. The analysts should ask these questions: (1) Who needs the data from inventories and monitoring? (2) Why do the various users need the data? (3) What kinds and amounts of data are required by various laws and users? (4) What are the priorities for various data?

Once the analysis is completed, BLM can attempt to answer the following questions about its current procedures: Do data currently being collected by inventory and monitoring satisfy the requirements of users and legal mandates (e.g., the Forest and Rangeland Renewable Resources Planning Act of 1974, the Federal Land Policy and Management Act of 1976, and the Public Rangelands Improvement Act of 1978)? If not, why not, and what are the consequences? Perhaps the demands for data from legal mandates and users exceed the Bureau's budgetary resources for collecting them. If this is suspected, BLM needs to reexamine its interpretation of what is required by law and by users. If the data exceed requirements of legal mandates, why do they, and what are the consequences? These questions require that BLM determine the extent to which the data collected are actually used in analysis, planning, and decisions. It is important to identify different information needs at local, regional, and national levels. Elsewhere in this chapter, we allude to criticism that BLM tries to collect too many data and explain how this occurs (see the subsections on "Local Planning" and "Measurement Methods"). Problems posed by having too many data can be as great as those of having too few.

The analysis suggested here should help BLM design inventory and monitoring that respond better to the law and users. Presumably, BLM knows the approximate cost of collecting various data and realizes that prohibitive costs or lack of money may negate collection of some data, jeopardize the precision or validity of others, or alter the frequency of collection. When policy or

scarcity of money restricts acquiring the desired data, BLM should have sound criteria for knowing how decisions regarding collection of data should be made and justified.

Planning

Over the past 20 years, BLM has often seemed to "change horses in midstream" and to make decisions that were difficult to understand. Perhaps this is partly the result of the controversial history of the Bureau and partly the result of failure to plan programs that were scientifically sound and at the same time pragmatic and politically realistic. In such circumstances, BLM could hardly be expected to compile a continuous record of successful planning, but even when its handicaps are taken into account, the BLM record leaves room for improvement. Although the Bureau has not been reluctant to seek outside counsel, it has often ignored the advice it sought and followed ill-conceived routes that eventually had to be abandoned. The recent history of range inventory in the Bureau reflects this same deficiency in planning.

Problems arise at two levels: first, at the management level, where decisions are made on how inventories and related efforts (e.g., monitoring) are to fit into an overall scheme; and second, at the local level, where specific inventories are carried out.

Management Planning

It is at the management level that standards, guidelines, and criteria for action at all other levels in the field must be determined. Consistency must be guided from the top. To the extent that management planning and planning at state and district levels are sound, consistent, and unconstrained, good results will be achieved. But there are constraints--many of them--and failure to allow for them in the planning process will create problems.

Inadequate manpower and funds have always restricted BLM as they did its predecessor. Yet the Natural Resource Defense Council (NRDC) suit with its court-imposed requirement to prepare 212 grazing environmental impact statements (EIS) between 1975 and 1988 (later reduced to 144) greatly increased the Bureau's workload. BLM, compounding the difficulties, determined that an adequate EIS required a large-scale inventory to be used both for land use planning and for the grazing EIS itself. Expenditures for inventories increased from $2.4 million in 1975 to a proposed $32.5 million for 1982. According to a Department of Interior (DOI) Office of Policy Analysis report (DOI 1980b), this information cost is high in view of the returns. The report contends that the escalation of inventories probably arose out of severe criticism of the lack of data in the early EIS, especially the grazing EIS for the Challis Planning Unit. It could be that the Bureau, in fact,

responded unwisely and invested too much in inventories, imposing unrealistic requirements of cost, manpower, and time.

Through discussions with BLM personnel (J.L. Hancock and D.E. Little, BLM, Washington, D.C., personal communication, 1981) and review of the BLM manual, it became clear that state and district offices have the authority to be flexible in implementing SVIM. But the committee believes that state and district offices have not used their flexibility to advantage, especially when deadlines and constraints of cost and manpower seemed to dictate some deviation from standard procedures. It may be questioned whether state and district offices really understand their authority to modify SVIM to achieve objectives, or whether a concern about obtaining the maximum amount of data in the event of court action is overriding.

Although instructions in the SVIM manual concerning stratification and sampling clearly imply flexibility, the record does not show that BLM has adjusted inventory intensity to the available resources. Deficiencies can probably be traced to limitations in personnel, planning, and training. When limited resources require an inventory of less than optimum intensity, its design requires knowledge of the precision and costs related to each phase. If it has not already done so, BLM should explore all available means of increasing the efficiency and cutting the cost of inventories.

Finally, BLM should continue to strive to plan, design, and structure its inventories and monitoring programs on the basis of sound resource management, and not in response to court mandates, criticism, or political pressures.

Local Planning

Planners at the local level must not only adhere to inventory guidelines, they must be in a position to make flexible and selective interpretations of local situations. They must also do this in such a way that data in local inventories remain compatible for aggregation.

Since the instructions in the manual for planning and conducting SVIM address many issues that are giving BLM problems, either the instructions are not understood, or those charged with local planning are, through errors in judgment, making range inventories more intensive than necessary and hence time-consuming and costly. This has led to the criticism that BLM, not knowing which data are really needed or whether decisions will be contested, is substituting quantity for quality in the inventory process.

The Bureau should capitalize on its knowledge of rangeland to make inventory and monitoring more efficient. Experienced Bureau personnel should have sufficient information about areas to be inventoried to identify specific problems or conflicts. This knowledge should dictate the scope of the inventory, the areas of emphasis, and the selection of procedures. The designers of the inventory and monitoring might ask these questions:

1. Do all lands need to be inventoried at the same intensity?
2. What questions are to be answered from the data?
3. If decisions depend on specific quantitative analyses, what are the criteria of these analyses for data?
4. What definitions and standards will be used for the data elements? Are they compatible with regional and national standards?
5. Are spatial and temporal sources of variability known and recognized in the inventory design (Ogden 1980)?
6. What will the final data be, and will they in fact provide the information sought?
7. Is the priority of various kinds of data appropriate?
8. Does the design allow for a prudent balance between quantity and quality of data (Bonham 1980)?
9. Will the amount and kinds of data in the inventory actually be used?

Data Collection

Classification and Stratification in Inventory

The primary purpose of classification is to communicate information and create order out of seemingly unrelated things. In land management, sound classification is the essential basis of stratification, inventory, and analysis of data for rangeland resources (Klemmedson et al. 1978, Driscoll 1980, Mueggler 1980, Wickware 1980). Driscoll elaborates on current deficiencies in land classification among land-managing agencies and organizations and prescribes the basic need for classification.

The basic classification BLM employs for its Integrated Habitat Inventory and Classification Systems should be natural and hierarchical. Natural classification is preferred because it uses primary properties of landscapes (e.g., vegetation, soil, and slope) without preconceptions about their use. Technical classification, in contrast, is based on preconceived notions of use. Natural classifications are actually multipurpose in that several technical classifications may be superimposed on a natural classification scheme. Thus information on suitability of land for livestock, timber, or wildlife, or vulnerability to erosion, or any other feature may be obtained from a natural classification and aggregated as needed. The hierarchical property enables aggregation of data to any higher level in a classification (Driscoll 1980, Mueggler 1980). Thus though the basic data would be site specific, it could be aggregated and simplified in a hierarchy for use at regional or national levels, or both.

Although the site classification BLM has been using is natural, it is not hierarchical. Neither has the range site classification originally developed and used by the Soil Conservation Service (SCS) ever been used hierarchically. The nomenclature employed by both SCS and BLM is descriptive (e.g., Sandy Plains Range site, 16- to 19-in. precipitation zone) and based on features of soil and

topography, but there is no logical scheme for grouping sites with similar properties. Hence the current use of range site data by BLM and SCS is of limited value beyond the local level in that it cannot be aggregated for management planning purposes at regional or national levels.

The committee recommends that BLM retain the range site as the basic unit for inventory and monitoring and revise the classification scheme into a hierarchy. This could be done by grouping into habitat types range sites that support or could support the same climax vegetation. The habitat type is the logical higher level in the hierarchy because it is (1) a natural classification, (2) based on climax vegetation, and (3) broader in scope than the range site (it should be noted that habitat type is similar but not identical to range site (Daubenmire 1970, Shiflet 1973, Pfister et al. 1977, Mueggler and Stewart 1980)). With a nomenclature based on climax vegetation, the range site can be integrated into the habitat type and into the higher levels of vegetation hierarchy as described in "A Component Land Classification for the United States--Status and Plans" (Driscoll et al. 1981). This will permit aggregation of data and information from specific sites for use at local, regional, and national levels. Disaggregation would also be possible.

In carrying out the stratification phases of SVIM, it is important that various steps be taken in a logical sequence. Range sites must be identified and delineated by range and soil scientists working together in the field. Independent vegetation and soil surveys will not be satisfactory. The purpose of BLM's final stratification under the SVIM is to place range sites in seral stages and current vegetation classes when they are different from climax vegetation. Stratification of the landscape into homogeneous units (e.g., range sites and vegetational units) is essential to useful sampling and to evaluation of range condition (Bonham 1980, Driscoll 1980, Pieper 1980). This means that classification of range site and current vegetation and delineation of the mapping unit must be completed before sampling, not during or after. Classification of the landscapes, based on range site, associated soils, and current vegetation, provides a means for developing a framework for storing and retrieving land information for management and planning purposes. That is not currently available in the BLM procedures.

The committee believes that the Bureau should emphasize stratification of the landscape into range sites, seral stages, or current vegetation, whether as part of the SVIM inventory or other inventories or monitoring operations. Because there will be increasing pressure on BLM to make its inventories less expensive, the Bureau should increase precision and reproducibility in designating various land strata. The object should be to devote sufficient effort to both the sampling and the stratification phases of inventorying and monitoring so that the data can be extrapolated with confidence and reliability and will produce sound results.

Sampling and Measurement Considerations

The appropriateness, accuracy, and precision of data collected are clearly critical (Bonham 1980, Menke 1980, Wagner 1980). This is true because (1) decisions must be made by BLM now, whether or not funds are adequate for complete inventories and regardless of political pressures, and (2) rangeland is being partitioned among more users under multiple-use management. Confrontations will continue to lead to court, and when both sides introduce inventory data, the statistical reliability of the Bureau's data and those of the adversary will be examined. Thus it behooves BLM to produce the most reliable data possible (Bonham 1980).

Ironically, BLM was its own worst enemy when it decided to allocate forage on the basis of forage production data. The SVIM that BLM designed and the complexity of the forage allocation model placed unrealistic demands on the inventory. Presumably, BLM was led into this trap in pursuit of the scientific data it felt would be needed to justify decisions, in or out of court. Predictably, the results have drawn criticism from several quarters. We discuss that criticism under three headings: (1) sampling and statistics, (2) measurement methods, and (3) quality control.

Sampling and Statistics. SVIM is a complex procedure requiring measurement of several physical and vegetal attributes, each with its own variability. Hence the demands for stratification, sampling, and measurement may vary with each attribute (Pieper 1980, Risser 1980, Taylor 1980). Although resolution of these demands is written into the SVIM procedure or handled in the preplanning analysis or inventory plan, certain decisions are left to the inventory team. The procedures in the SVIM manual allow latitude for ecosystem variation and coping with the sampling problems posed by stratification. Sampling within selected members of each established strata involves transects and plots in a design that is largely systematic, but with some elements of randomness. The BLM range staff, however, has been disturbingly lax in applying statistical principles to sampling designs and data analysis. The staff is either naive in its understanding of random sampling and various statistical tests, or it is taking liberties in the use of statistics that cast doubt on the validity of inventory data and even entire inventories. (It is important to note that BLM is not alone in naivete or disregard of criteria for recognized statistical tests; this is commonly observed, though not excused, among scientists as well.)

Both systematic and random sampling are important when used appropriately. They also have limitations, however, and when used inappropriately may lead to erroneous conclusions. These problems were discussed by Bonham (1980), and Cochran (1977) has treated sampling designs. Cochran discusses the advantages and disadvantages of random and systematic sampling, their variations, and when particular designs can be safely used. BLM should decide

how it expects to use and test its data before plans are designed. It is worth noting here that the Forest Service also uses systematic sampling in the collection of some of its range inventory data and it has done so without serious criticism.

BLM should conduct inventories and monitoring so as to characterize variation in the data and to report the data with errors of measurement, confidence limits, and probabilities. Reporting these statistics should allow for some safety margin in management decisions and protect the credibility of the Bureau.

Measurement Methods. The complexity of SVIM is primarily a function of the Bureau's decision to allocate forage and determine initial grazing capacity on the basis of forage production. The requirement for data for these two determinations, including the adjustment factors for the allocation model (see the section on "Interpretation of Inventory" below), are extensive and, in the opinion of this committee, beyond current capabilities of BLM. Recent changes contemplated in Bureau policy indicate that BLM, or its superiors in DOI, now realize this.

Most measurements (e.g., estimate of weight and step-point transect) in SVIM are sound and appropriate to its purpose (Pieper 1980, Risser 1980). However, BLM designed SVIM with an excessive degree of measurement detail. Moreover, the amount of detail some measurements required frequently is not consistent or balanced with the overall sampling design. An example is the determination of vegetation production by weight estimate. According to the SVIM manual, weight of plant production is estimated by species in four height classes in each of a minimum of 10 plots (additional plots may be used). Ancillary data on weight estimate include (1) average availability, phenology, and use for each species in each plot, (2) form and age class for each plant of grasses and forbs and average height by grass and forb species in 3 of the 10 plots, and (3) clipping by species in at least 2 of the 10 plots. Although BLM may have reasons for each kind of data, we question whether eventually all of them are used or required. Moreover, the number of observations (n) for any attribute (e.g., yield, phenology, and utilization) measured seems inconsistent with the degree of refinement in data collection portrayed by the example above and the SVIM manual. In reality, where systematic sampling is employed, BLM has inflated n values.

As with other agencies gathering statistical data, BLM can profit from techniques for inventory and monitoring that are consistent with data requirements. Wagner's (1980) discussion of eight different kinds of animal census and comments by Siniff (1980) illustrate both the importance of choosing the proper method and the variety of factors that must be considered in selecting techniques. The questions one would ask in selecting an animal census method (Siniff 1980, Wagner 1980) concerning proposed use of the data, requirements for accuracy, and cost should be asked in sampling other resources (Bonham 1980, Menke 1980, Pieper 1980, Risser

1980). With careful choice of methods, the quality of data, including accuracy and precision, can frequently be improved at the same or reduced costs. A review of the detail required by different portions of the SVIM procedure or proposed monitoring studies is therefore appropriate. Techniques that fit the above description but are not mentioned in the workshop papers (Risser 1980, Wagner 1980) include rated plots and ranked sets sampling (Morris 1963, Halls and Dell 1966). The objective of these methods is to increase the efficiency of data collection. Clearly, BLM must be more efficient in its inventory and monitoring.

Development of methods in two areas are appropriate. The first is multistage sampling, including use of remote sensing to increase the efficiency of stratification and sampling soil and vegetation (Wickware 1980). The second is animal census (Siniff 1980, Wagner 1980). Although BLM is constrained by political pressure and inadequate funds, the lack of census information within the organization has clearly hurt BLM's ability to meet its obligations (Wagner 1980).

Quality Control. Quality control is essential to good inventory data (Brown 1954). It must be exercised wherever human judgment may influence final results, wherever opportunity for bias is large, and wherever credibility of decisions is at stake. The committee has not been geared to determine how well BLM controls quality in rangeland inventories; but we suspect there may be room for improvement, and we offer the following suggestions.

Quality of an inventory depends on training of crews, especially in measurement. Good quality data, particularly those that vary seasonally, require continuous training and recalibration in the field (Risser 1980). Several questions help focus on quality control pertinent to range inventory:

1. Were the data collected in a manner that will meet standards of reliability? Do the field crews have confidence in the methods?
2. How well educated are the crews in inventory procedures?
3. Did the design allow for correction in the data based on known observer characteristics, or were these characteristics confounded with strata such as to bias the results (Risser 1980)?

Another aspect of quality control is continuity between the field and the tabulation and summarization. Specifically, do the field personnel work together closely enough with the computer analysts in the analysis of data? The former are in some respects in a better position to check calculations at each stage than the computer analyst who may be unfamiliar with field situations. Quality control may suffer when the computer plays as large a role in analysis as it does in BLM.

Finally, the Bureau should not allow the computers to influence unduly the design of inventory needs. Prescriptions for inventory and monitoring studies and their analysis should be made in terms of management objectives and kinds and amounts of data needed, and not

in terms of the capacity of the computer to absorb and manipulate data.

Interpretation of Inventory

Initial Grazing Capacity

The principal controversy surrounding SVIM concerns the vegetation inventory. In particular, BLM's use of forage yields determined by weight estimate (Risser 1980) to calculate initial grazing capacity has caused widespread disagreement. The forage yields are adjusted, by various factors, to total average yield per unit area. Correction factors include adjustments for moisture content and use by herbivores, and adjustment to peak plant development and average growing conditions. After further adjustments of the total average yield for plant maintenance, range suitability, susceptibility of soil to erosion, slope steepness, and distance to water, the residual yield is the forage that can be allocated to consumption.

Analysis of the above procedure for determining allocatable forage leads to the following observations.

1. The procedure is based on the vegetation characteristic (i.e., current yield). Compared to other characteristics of vegetation, yield is the most variable during and between years, the most readily changed by use, and the most time-consuming vegetal parameter to measure (Risser 1980).
2. In each of the adjustment coefficients, inherent errors make accuracy usually impossible to determine (Menke 1980). Estimates of adjustment coefficients with reasonable confidence and error (Bonham 1980) require more sampling than is usual for SVIM inventories.
3. Some of the adjustments (e.g., range suitability, susceptibility of soil to erosion, and slope steepness) are highly subjective and tend to be on the conservative side (Despain 1977).
4. The effect of several coefficients, each with its own bias and error, on the allocation model is unknown. (See the analysis for the Forage Allocation Workshop in Chapter 1.)

These observations force one to question the reliability of SVIM for determining grazing capacity (Smith 1980). Too many subjective judgments and sources of error are involved in SVIM for a prudent person to rely on it solely (Schmautz 1980, Smith 1980). Other evidence and information, such as past stocking records (Pendleton 1980), trends in range condition, and experienced professional judgment, should be used to corroborate grazing capacity determinations arrived at by SVIM.

Range Condition and Trend

BLM determines range condition and trend in accordance with current techniques for these concepts; the Forest Service and SCS do likewise. However, there has been increasing criticism of the range condition method in recent years. That criticism was reflected in papers by Smith (1980), Schmautz (1980), and Pendleton (1980). Although the concept of range condition was developed and used to rate range communities by ecological succession, the almost universal use of a terminology (excellent, good, fair, poor) that equates excellent range condition with the climax stage of succession has led to the connotation of value or quality for the various ecological stages. Hence, in practice, various stages or condition classes are frequently viewed in terms of their relative value as well as ecological status (Smith 1980).

In the Southern Prairie, where the condition method was developed, successional stage is correlated with quality of forage for livestock. Hence the conflict over duality of meaning of terms is kept to a minimum. However, where the ecological stage of plant communities is not correlated with quality for a specific use (i.e., succession and quality do not progress in a parallel fashion), the problem alluded to above arises, and controversy results. When one considers that the quality of an ecological stage may differ for any given use, or value, it is not difficult to see why changes in the range condition classification are needed.

Continued use of the current system will only prolong BLM's difficulties. The Range Inventory Standardization Committee (1980) of the Society for Range Management has proposed replacing range condition with two other ratings. The first would recognize the ecological status of plant communities with the climax or potential natural vegetation as the base and employ ecological terminology. The second would be oriented toward use by cattle, wildlife, watershed, recreation, and so on, and would rate ecological stages by value relative to specific uses. The committee suggests that the Bureau consider the proposed new ratings and that they encourage their development, if they are promising and compatible with BLM's needs.

Training

Inventories require a large investment and much labor. They depend heavily on the judgment of the people conducting them. Therefore it is essential that inventory teams be capable and level-headed. In particular, the people who plan the inventory should be capable of designing inventories that are statistically sound and consistent with inventory objectives. Training of field personnel should include not only a thorough understanding of the various methods employed--including the scientific background on which methods are based and sources of error and bias--but also the statistical implications of various sampling procedures (Cochran 1977) and the methods used to analyze the data.

Current range inventory is a full-time activity for assigned BLM personnel, and they should be maintained in a peak state of training. Currently, inventories have been organized and supervised at the district rather than the state level. Presumably, this causes variation in training and standards and, with it, variation in quality among districts. BLM should consider a more centralized organization and training of inventory crews to achieve more uniformity throughout the Bureau.

Expertise and Personnel Management

Many of BLM's problems with inventory and monitoring are related to expertise and management. These deficiencies have contributed to unsatisfactory inventories and a loss of credibility among users, federal counterparts, and scientists. Although expertise of the staff could be improved throughout, it appears to be most deficient at the highest (Wagner 1980) and lowest administrative levels. The BLM staff with responsibilities in range resources (including Job Series for Resource Manager, Natural Resource Specialist, Range Conservationist, and Range Technician) has changed from a group trained in range management to one in which 47 percent have B.S. degrees in various fields of agriculture, biology, and the social sciences (D. Vail, BLM, Washington, D.C., personal communication, 1981). The change has been in response to the multiple resource and managerial mandates of Congress as well as to the NRDC suit and the EIS process. Demands of the EIS process also frequently drained away from other assignments the time of the more competent staff. Although about 13 percent of the BLM range staff now have M.S. degrees, only one has a Ph.D. degree (D. Vail, personal communication, 1981). Despite changes in hiring policies, BLM still lacks people with specific expertise for key jobs, particularly at the upper levels (Wagner 1980).

In addition to operating under a ceiling imposed by Congress and the administration that keeps the number of personnel inadequate to perform the job at hand, the Bureau has never had a staff of the scientific and technical ability to design, train people, and administer the range management mandated, especially recently. Failure to acquire this talent is probably the result of inability on the part of the Bureau to attract the right kinds of people.

Over the past several years, BLM has asked frequently for advice. This contract with the NRC is a recent example. Perhaps no agency can be expected to satisfy all its scientific needs all the time with its own staff. The committee contends, however, that many of its calls for assistance could have been avoided if the Bureau had had a staff of scientific and technical competence.

Some of the change in educational background of the BLM range staff alluded to above has been designed to recruit certain kinds of expertise; some of it has been the result of relaxed and inadequate requirements of the Office of Personnel Management now specified for the Range Conservationist position. Under the new requirements, graduates from various disciplines with only 12 units of range

management can qualify as Range Conservationists. Standards for the position have recently been upgraded to demand more stress on preparation in land management, but BLM is still strapped with inadequately trained Range Conservationists. If BLM has used higher standards for hiring than its federal counterparts, then there is even more reason for concern. Not only are these "12-unit range managers" minimally prepared in range science, but an increasing percentage of them have been reared in cities and are unfamiliar with the ways of the western range.

Actions that the committee believes would be prudent for the Bureau to consider are the following:

1. Range staff personnel should be encouraged to participate in technical and professional societies. The executive secretary of the Society for Range Management (SRM) reports that in 1978 only 35 percent of BLM Range Conservationists belonged to SRM (F.E. Kinsinger, Society for Rangeland Management, Denver, Colorado personal communication, 1981); corresponding figures for Forest Service and SCS were 75 and 65 percent, respectively. Since 1978, the percentage of BLM Range Conservationists in SRM has declined.
2. BLM needs to retrain its range staff. Seminars, short courses, and advanced professional training, if judiciously administered, can improve expertise of the staff.
3. The committee suspects that range staff, especially in lower ranks, are not actively engaged in self-improvement in technical fields, creative thinking, planning, and problem solving. When schedules do not allow for such activities, the success of projects is impaired and quality of work declines.

RECOMMENDATIONS

The major recommendations of the committee are as follows:

1. The Bureau's range management program should be redesigned to put in place a program that is logical, scientifically sound, credible to users and constituents, economically feasible, and consistent over time.
2. The range inventory should be scaled down to a level that the Bureau can handle with its own resources. The inventory should be restricted to stratification of the landscape and measurement of permanent features of ecosystems, including designation of range sites and characterization of plant communities by their stable features. Forage production should be measured only in special cases.
3. Monitoring should complement the range inventory. It should be pragmatic, site specific, and scientifically sound. Methods and the components and attributes monitored should be selected on the basis of their ability to detect changes in the ecosystem and its use in response to specific uses or treatments.

4. The precise data required by laws and users for management purposes should be identified and analyzed. This will guide BLM in carrying out its inventory and monitoring in the most useful, efficient, and economical manner.

5. The range site should be retained as the basic stratification unit for inventory and monitoring. A hierarchical classification should be developed that will permit a grouping of range sites into habitat types and higher levels of vegetation hierarchy as proposed in "A Component Land Classification for the United States--Status and Plans." This classification would facilitate aggregation of information from specific sites for planning at local, regional, and national levels.

6. The Bureau should stop determining grazing capacity solely from SVIM forage production data. Alternatives include past stocking, trends in range condition, and experienced judgment, together with forage production when available. Determination of grazing capacity should be followed by monitoring and stocking rates adjusted to meet objectives.

7. To improve inventory data, the Bureau should (a) apply known sampling and statistical methods, (b) balance quantity with quality of inventory data, mostly through judicious selection of fewer range characteristics for measurement, and (c) emphasize greater quality control over data obtained from inventory and monitoring.

8. The Bureau should support research efforts to replace the current range condition classification with a dual rating system, i.e., one that recognizes the ecological status of plant communities and another that recognizes relative quality or value of successional stages of plant communities for various uses.

9. Inventory and monitoring teams should be staffed with capable, experienced people well-trained in range and allied sciences and in inventory, sampling, and statistical methods. Training of inventory crews should be centralized and continuous throughout the inventory season.

10. Competence of the range management staff should be improved through (a) recruitment of specialists to help solve the more technical problems, (b) improvements in personnel management and training policies, and (c) the fostering of professionalism within the Bureau.

11. The administration, Congress, DOI, and the public should recognize that BLM is not wholly responsible for its failures. Historically, the Bureau has been underfunded and understaffed, often intentionally to maintain the status quo and to serve vested interests. The Bureau's mandate has been impossible to carry out under the best of circumstances. Although the problems the Bureau faces in its inventory and monitoring program can be alleviated by attention to the other recommendations of the committee, improvement to a satisfactory level will require more money for the Bureau.

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Chapter 3

IMPACTS OF GRAZING INTENSITY AND SPECIALIZED GRAZING SYSTEMS ON THE USE AND VALUE OF RANGELAND

INTRODUCTION

A major use of rangeland is grazing by domestic livestock. Since about 1850 the ecology of western arid and semiarid rangeland has largely been shaped by the interaction of grazing and intermittent drought.

Managers have long believed that properly vegetated rangeland provides an optimum yield of all resource products sought--stable watershed, clear water, and abundant wildlife, recreational opportunities, and food and fiber. Rangeland in poor condition was thought to have gotten that way because of poorly managed livestock grazing, and it was thought that no grazing or less grazing would restore, or at least improve, it.

Specialized grazing systems, which combine periods of use and nonuse, were proposed to improve ranges that had deteriorated under improper grazing. Data, however, do not support many of the commonly offered reasons for using these systems. Results from research have been inconsistent and unexplainable. The one certainty is that there is no single grazing system that will improve rangeland everywhere.

Grazing systems should minimize adverse plant response to grazing intensity, frequency, selectivity, and seasonality and should provide as nutritious and abundant a feed supply as possible for the animals. Flexibility is the key for success. Strict rules for grazing rotation are counterproductive.

Late-season grazing following earlier deferment has been recommended for at least 75 years because seeds trampled by livestock are thought to enhance production of new seedlings and thus improve the range. However, the literature does not support this. In addition, little is known about the effect of grazing on plants after flowering.

Plants do respond favorably to rest from grazing. Research however, has not discovered why this occurs, nor has it provided guidelines for predicting the degree of the improvement. Research has for the most part concentrated on single- or double-factor treatments, and the results, while useful, do not provide complete answers. Research controls have been inadequate to isolate the factors affecting the experimental results. Most of the available information has come from observations of failures and successes through experience in managing all interacting environmental factors at once (Heady 1981).

The rest-rotation grazing system endorsed by BLM is based on general plant response and ignores the nutritional needs of animals. The system increases stock densities on part of the area by at least 25 percent, and usually more, and holds the livestock on one pasture for too long during critical nutritional periods (Herbel 1974). Although it is good for many plants, the system is not generally good for livestock.

Perhaps the most important reason to use a specialized grazing system is to combat the effects of selective grazing and to force uniform grazing distribution. Often ranges are overgrazed in places but underutilized overall because animals are permitted to be overly selective and to concentrate grazing in too small an area. A grazing system should alter these patterns without leading to extended high-intensity defoliation.

VEGETATION PRODUCTION AND COMPOSITION

The grazing capacity of most of the western range declined significantly in the last two decades of the nineteenth century because of the interaction of grazing, perhaps at its peak then, and periodic drought. Total vegetal production, however, probably did not decrease significantly. Production of plants preferred by the herbivores (grasses) declined, but production of competing, less preferred plants (shrubs) increased. Thus an important influence of overgrazing on vegetation is a change in species composition.

The effect of grazing on total vegetal production is much less significant than the effect of climate. The correlation between annual vegetal production and precipitation is very high, on the order of 0.9. Similarly, grazing is not the most important factor in determining species composition. It is becoming increasingly apparent that weather variation may be as important (Norton 1981).

The process of composition change due to grazing has been modeled by Dyksterhuis for the midwestern prairies. This model has been applied throughout the West by various federal agencies. But its use is being seriously questioned for the arid and semiarid shrub-grass range (Norton 1981) because the assumption on which it is based, that if range deterioration was caused by overgrazing then reduced grazing should allow secondary successional processes to generate a natural improvement in range condition, is not supported by data for semiarid shrub-grass range. Grazing <u>can</u> accelerate a change to shrub dominance, but reduced grazing, and even elimination of grazing, cannot reverse the change in any reasonable period of time (Norton 1981).

The role that specialized grazing systems play in vegetation change has not been defined by research. Theoretically, a specialized system should allow for adequate plant reproduction. It should also spread grazing impacts more evenly over the plant population and thus reduce the competitive advantage of less palatable plants. A rigid system of grazing restricted by dates rather than plant requirements will not work in a drought. And a grazing system that will not work in a drought will not work.

To determine whether a grazing system is accomplishing its objectives, both animal response and plant response need to be considered. Measurement and interpretation of plant response are difficult and are currently determined on the basis of changes in range condition, which is designated as poor, fair, good, and excellent as the vegetation approaches climax. This range condition concept implies that regardless of the kind of land use involved, climax vegetation is better than any subclimax vegetation. The concept cannot deal with land use and ecological status simultaneously. It should probably be expanded to include two separate ratings. One could assess the relationship between existing and climax vegetation, and the other could recognize the capability of the site to support various uses.

As currently implemented by the BLM (as of fall 1980), range condition is based on species composition derived from current vegetal production, with that production being adjusted to an average precipitation year. Use of biomass as the parameter of vegetation composition to determine range condition is not reliable because of the high variability in annual production caused by weather. This variation is often of such magnitude during subnormal precipitation that it even masks the effects of a grazing treatment, making it almost impossible to determine if the vegetational changes are the result of the grazing system or the weather.

The wide annual fluctuations in plant yield and associated foliage cover make these two parameters extremely poor ones to use to monitor vegetational trend. More accurate parameters for detection of trend are basal area, density (number/area), and frequency of occurrence. Research is needed to develop a simple, rapid method to produce reliable data for the early detection of vegetational trend. This method must rely on measurable attributes of secondary succession. In the past, range managers have held that secondary succession follows a single-path successional sere. If that were true, tracing the ecological decline of plant community type from climax to subclimax and back to climax would, of course, pose no problem. However, succession actually proceeds along many paths. The theory of multipath succession suggests that for a given successional stage more than one plant community type is involved (Bartolome 1981). Also, it is improbable that all the plant community types within a successional stage would be of equal value for any single use, nor would they respond similarly to treatment.

WATERSHED CHARACTERISTICS

Livestock grazing affects watershed hydrologic properties by removing protective vegetation and by causing trampling disturbances. Reductions in the vegetation cover increase the impact of raindrops, decrease soil organic matter and soil aggregates, increase surface vesicular crusts, and decrease infiltration rates (Blackburn 1981). Other detrimental impacts include increased overland flow, reduced soil water content, and increased erosion.

Most studies of watershed parameters have evaluated the impact of grazing after the treatments have been in effect for 10-20 years. These studies have used a variety of methods and usually have compared responses of selected variables from areas exposed to various intensities and durations of grazing to those from an ungrazed area. The literature has many examples of the adverse impacts of abusive grazing on watersheds. However, few research projects have studied seasonal or long-term hydrologic impacts of moderate grazing (Blackburn 1981).

On seeded rangeland in the intermountain west, significant declines in infiltration rates occur over a 2- to 3-year period following plowing for seedbed preparation, but after crested wheatgrass (*Agropyron desertorum*) is established, grazing does not appear to cause a further reduction in infiltration rates. Recovery of infiltration to preplowing rates seems to be impossible as long as grazing is continued. Grazing does not increase sediment production beyond that caused by plowing and seeding. Trampling on these sites causes a decline in infiltration rates, but regardless of trampling, sediment yields remain uniform after grass cover reaches 50 percent (Dadkhah and Gifford 1980).

Grazing impacts on watersheds were also recorded on the salt-desert shrub rangeland, where runoff from grazed watersheds averaged 131-140 percent of that from ungrazed watersheds and sediment yield ranged from 134 to 196 percent of that from ungrazed watersheds (Lusby 1979). Reduction of grazing pressure from heavy continuous to moderate with summers deferred resulted in a 71 percent decrease in sediment yield over a 4-year period in semidesert range of the Southwest (Aldon and Garcia 1973). The work of Rich and Reynolds (1963) in the chaparral of central Arizona indicated that proper utilization (40 percent) of perennial grasses caused no measurable change in runoff or erosion compared to no grazing.

The few data available strongly suggest that hydrologic differences between lightly grazed and moderately continuously grazed pastures are insignificant. Therefore there appears to be no hydrologic advantage to grazing a watershed lightly at 30-40 percent utilization rather than moderately at 45-55 percent.

Few data are available to quantify the hydrologic impact of specialized grazing systems since there is no published evidence that shows any grazing system to increase long-term plant and litter cover on watersheds consistently and significantly. There is some evidence that a four-pasture deferred-rotation system, in Texas at least, is hydrologically similar to ungrazed areas, and high-intensity, low-frequency grazing systems are similar hydrologically to heavy continuous grazing in the rolling plains of Texas and to moderate grazing in the Edwards Plateau of Texas.

Since vegetational cover is related to both erosion control and infiltration rates, managers must be careful in applying specialized grazing systems in the 8- to 12-in. (203 to 305 mm) precipitation zone, which supports relatively little vegetational cover and thus has a high potential for erosion.

WETLANDS AND RIPARIAN HABITAT

Management of wetland and riparian zones is a major source of potential conflict. These zones are the focal points for most of the multiple use values of rangeland.

Much information exists on the influence of grazing systems and intensities on plant communities, livestock, and watersheds but not specifically on riparian habitats. Information on grazing-wildlife interactions in riparian zones is also limited. Despite these limitations, it appears that grazing systems are not as effective for restoring depleted riparian habitats as reductions in intensities of grazing (Skovlin 1981). Cattle prefer riparian and wetland herbage to upland herbage unless their distribution is rigidly controlled. Furthermore, most grazing systems concentrate use, and the rest period may not be sufficient to ameliorate the effects of the heavy grazing by the cattle on riparian vegetation.

Recent reports have shown that aquatic environments in the arid and semiarid West are adversely influenced by uncontrolled and heavy grazing. The extent to which they may be affected by moderate or light controlled grazing has not been adequately studied (Skovlin 1981, Platts and Raleigh 1981). Only one study has shown evidence of improved riparian conditions as a result of grazing management actions. These studies, though not experimentally sound or statistically reliable, showed evidence of improved riparian and aquatic environments in 4-7 years after full protection from livestock by fencing. Estimates of acceptable shrub recovery varied from 5 to 8 years in most regions, and fish biomass usually doubled in 3-5 years. Bird and mammal populations showed an equally striking response (Skovlin 1981).

In riparian zones, vegetation abuse caused by grazing often affects birds, mostly nongame and waterfowl, small mammals, invertebrates, and large mammals. Literature on responses of these animals is meager.

For songbirds, grazing can affect the composition of their community. When the riparian zone vegetation changes from herbaceous to woody or woody to herbaceous, the community composition is altered because different species have different nesting and feeding requirements.

Waterfowl in wetlands may be adversely affected by heavy grazing during breeding, nesting, and brood-rearing periods. Apparently, grazing affects waterfowl rearing success largely by reducing herbaceous cover and altering plant structure, thereby exposing them to predators. Specialized rotational grazing systems may reduce these adverse impacts (Skovlin 1981). Certain species, notably the blue-winged teal (*Anas discors*), are benefited by moderate grazing over no grazing.

Small mammal diversity may increase directly with increased grazing pressure. Abundance and biomass of mammals, however, often diminish. Different species of small mammals react in different ways to grazing intensity, but, in general, fewer species are benefited by heavy grazing than by no grazing. Late-season grazing, rather than early, provides maximum cover for good small mammal habitat. Pocket

gopher (Geomyidae) response to grazing seems to be highly variable and is perhaps more closely related to how succession or current grazing affects availability of their preferred forb diet than to the grazing treatment itself.

Very little information exists on the effects of grazing on invertebrates. That which is available, however, shows that heavy grazing decreases both diversity and abundance of invertebrates over no grazing. Herbaceous litter is undoubtedly important to many invertebrates, and grazing probably adversely affects soil-burrowing insects. Some invertebrate orders such as Orthoptera (grasshoppers and crickets), however, require compacted soils.

Aquatic environments in cool, humid climates apparently respond to grazing differently from those in more arid areas. In the former, streamside shade can limit aquatic plant production and invertebrates that provide food for cold water fish. In these areas in the Pacific Northwest, fish response to unshaded areas and even to cattle grazing was variable (Skovlin 1981). In mountainous watersheds, streambank erosion may be more directly related to winter hydrologic phenomena (such as ice flows and spring freshets) than to any moderate livestock management system.

Bacterial contamination of water on most grazed watersheds seems to be of small consequence (Skovlin 1981). Bacterial contamination is generally slight, and streams easily meet the standards for wildland water.

Ten choices exist for grazing management in areas with riparian zones. They center on (1) improved livestock distribution, (2) periods of grazing deferment and rest, and (3) fencing combinations.

a. Do nothing
b. Improve distribution for greater upland use within the existing system; i.e., reduce use in riparian zone
c. Change season of livestock use
d. Implement specialized rotational grazing seasons or systems for restoration of riparian zones and improved livestock production in the uplands
e. Rest the entire grazing unit for 5 years or until target levels of recovery in riparian zone have been achieved
f. Fence meadow flood plain for controlled use of entire riparian zone environment (and, consequently, the uplands)
g. Fence streamside corridor for complete habitat preservation (provide access to water where needed)
h. Combinations of two or more of above solutions
i. Revegetate with woody cover and apply e, f, or g
j. Eliminate grazing

The choice depends on the degree of riparian depletion, the speed with which recovery is desired, the level of restoration desired, and the importance of the zone for other values such as fisheries, recreation, and rare or endangered species habitat.

FAUNAL COMPOSITION AND PRODUCTIVITY

Impacts of livestock grazing on wildlife in general are poorly understood, and our knowledge of impacts of various selective grazing systems is even more superficial (Evans 1981, Carpenter 1981). Beyond a few generalizations regarding extremes, such as the knowledge that heavy long-term overgrazing causes negative impacts, existing data fail to support broadly based principles required to guide managers of rangeland and its fauna. Overall, the recognition that vegetation diversity decreases with grazing intensity, especially under continuous grazing, is basic to understanding and predicting impacts of domestic livestock management on wildlife populations (Carpenter 1981).

Traditionally, wildlife has been viewed as "wild livestock" and characterized in agricultural terminology of numbers, distribution, and productivity. But wild populations may also be characterized in terms of their position and function in the ecosystem's dominance hierarchy and seral associations and by their role vis a vis other fauna (including man), and their stage and direction in the evolution of the species (Evans 1981).

The characteristics defining a wild population are the product of the population's past and present environments. Livestock grazing, like all major factors in the grazing ecosystem, generates many environmental impacts on wild populations. Impacts may be direct, as when livestock modify or become a part of a species's particular ecological requirements (e.g., when livestock and wildlife have the same or similar habit and food preferences), or indirect, as when livestock-induced modifications in the ecosystem cause pertinent environmental pressures (Evans 1981).

Numbers, kinds, and distributions of livestock within a given ecosystem are largely independent of the forces governing abundance, diversity, and distribution of wildlife. Until about 150 years ago, there were virtually no livestock in the West. Today, 70 percent of the western lands are grazed at some time during the year. As livestock numbers increased rapidly between 1885 and 1920, livestock management practices became more complex, evolving from simply letting animals graze in a near-wild state to implementing increasingly more sophisticated systems of pasture deferment and rotation, brush control, range seeding, and increased fencing. Although livestock adapt easily to these changes, the adjustment for wildlife is more difficult (Evans 1981). To a great extent, success of wildlife species depends on their ability to survive more and more complicated situations resulting from man's preoccupation with increasing livestock production.

Livestock management programs using specialized rotational grazing systems are usually not designed to accommodate significant increases of potentially competing wild herbivores. Presumed "benefits" to wildlife from selected grazing systems are regrowth of vegetation on the areas recently vacated by livestock. If these benefits are realized, resulting in an increase in wild herbivores during the growing season, the benefits accrued from pasture deferment could be negated and the intent of the grazing system thwarted.

Impacts on wild species are unavoidable. However, livestock species, grazing intensities, and grazing management systems that could result in displacement of wildlife species should be resisted (Evans 1981). The land manager must increase or maintain wild animal diversity where costs and benefits are known. The population size of a particular wildlife species is less important than the diversity and ecological function of the wildlife species.

Specialized grazing systems should provide an ecosystem that contributes especially to wildlife diversity. In general, specialized grazing systems are aimed at improving ecological range condition for livestock production. A more proper approach would be to require that the entire ecosystem be healthy (Evans 1981). The immediate demand on rangeland managers is to halt practices that will contribute to any further irreversible ecological changes associated with livestock grazing. Management for human benefits, including livestock products, should fit into the total ecosystem instead of restructuring it around a single purpose. Once faunal diversity is assured, the manager may attempt adjustments in relative species biomass to meet the objectives of multiple uses.

LIVESTOCK

Over the past few years the BLM has used three general management practices that directly or indirectly affect stocking rates and presumably livestock production. All of them have had the goal of "improving the range" in the broad sense. Direct adjustments (usually reductions) in numbers of animals permitted on grazing allotments is one practice. A second is implementation of specialized rotational grazing systems. Direct manipulations of plant communities (vegetation type conversions) is the third, but it has not been widely used by BLM since 1976. These practices can have considerable influence on livestock production, and, generally, the third is the only one that has notably increased animal production (Malechek 1981).

Animal production on a per-head basis changes little as the stocking rate is increased at the "light" end of the stocking rate spectrum, but as stocking increases from "moderate" through "heavy," the yield per animal declines in a near-linear fashion. The declining function appears to begin at stocking rates that exceed a critical level (Malechek 1981, Rittenhouse 1981). This critical level, as an example, has been suggested as one that leaves about 179 lb/acre (200 kg/ha) of forage remaining at the close of the grazing period on eastern Colorado blue grama (Bouteloua gracilis) range (Bement 1969). To achieve optimum animal yields the manager must have the flexibility to adjust stocking rates to keep forage availability above that critical level. For the most part, the agency does not allow public land managers to adjust short-term stocking rates on public lands, even though the need to do so is obvious if range forage is to be efficiently used. BLM should strive for economically optimum stocking rates and should even consider

maximizing return from livestock grazing on some of its lands. A prime candidate for the latter consideration is the crested wheatgrass seedings that were established in the 1950s to increase livestock forage (Malechek 1981).

A reduction in stocking rate does not necessarily imply a corresponding reduction in animal production. If forage availability on the grazing allotment is consistently below the critical level suggested earlier, a reduction in livestock could result in increased per-head productivity of the animals remaining because more forage would be available to the remaining animals. If, prior to grazing reduction, all livestock were nutritionally deprived of energy, protein, or both, herd production would be well below its potential. Removal of even a few livestock could have a beneficial effect on the other animals, perhaps even to the extent of overcoming much of the production lost from the removed animals (Malechek 1981).

Evidence in the literature does not provide compelling support for the use of specialized grazing systems for improving livestock production. The main purpose of specialized grazing systems has been to improve range condition while maintaining grazing. About the best that can be expected is that animal production on a per-head basis will not decline and that vegetal composition will improve under specialized grazing. Presumably, as range condition improves, usable forage increases, and thus grazing capacity grows (Malechek 1981). With more animals, productivity on a land area basis would be expected to increase even though production per head would probably not change.

Explanations for a lower than expected livestock response for specialized grazing systems usually rely on aspects of animal nutrition. The quantity and quality of forage supply is constantly changing. The animals' forage needs are also continually changing as they enter various physiological states and growth stages in the annual production cycle. If grazing systems are to successfully maintain or increase livestock response on a per-head basis, the systems must cater to animal needs. At the least, more attention must be given to livestock and wild herbivore requirements than has been given in the past when federal land managers developed specialized grazing systems mainly to improve rangeland. Few, if any, extra costs are involved to improve animal productivity while improving range condition. It is in the best interest of both the permittee and the public to graze public range <u>efficiently</u>. Grazing systems that accumulate large quantities of mature and near-mature herbage, such as the Hormay-type rest-rotation schemes, will result in reduced animal nutrition and performance (Malechek 1981).

Scientists are beginning to learn how important behavior is in affecting animal production. A herd or flock that has become adapted to a range and its nutritional characteristics would certainly be expected to respond negatively to any dramatic change in a grazing system that would require the animals to alter their behavior seriously (Rittenhouse 1981). The stress results in lowered short-term animal productivity. The key to obtaining as great a positive response as possible from animals grazing in a specialized system is to have the flexibility to alter the management when it is

obvious the animals are under stress. This stress can easily occur when the grazing plan calls for concentrating too many animals in one place for too long a period.

Along with any grazing plan, time-tested animal husbandry practices such as pregnancy evaluation and culling unproductive cows, fertility testing of bulls, using genetically improved animals, and following standard animal health practices should be emphasized. An increase in percentage calf crop from 70 percent, which is common in much of the West, to 85 percent through application of these measures can result in a 200 percent increase in net return per cow in the breeding herd (Minyard 1973). Federal land managers should help permittees improve management of the livestock as well as the range.

Perhaps the most important reason to use a specialized grazing system for livestock is that such a system can be more effective in coping with drought than can continuous grazing, and saving both hay and the range during drought is economically prudent.

CONCLUSIONS AND RECOMMENDATIONS

General

1. Grazing impacts are not single-factor influences. They are confounded and differ in relative importance in different situations.

2. Research into specialized grazing systems has been only minimally successful in explaining why certain results were obtained and in predicting what will happen if a given system is applied in another location.

3. A grazing system should accomplish two important goals to be successful: (1) it should evenly distribute livestock grazing over the entire grazing unit, and (2) it should reduce the high degree of selectivity animals exercise when permitted to do so. Though not well researched, systems of short-duration grazing have offered empirical evidence for achieving a high degree of success for both.

Vegetation Production and Composition

1. The influence of grazing and weather as interacting forces on vegetation has not been adequately separated into its component parts. Available data indicate that in the West weather overrides grazing in its influence on vegetation production.

2. Comparisons of specialized rotation grazing systems with continuous grazing in regard to their influence on vegetation have yielded confusing, if not conflicting, results. There are at least two reasons for this: (1) The rotation schemes are usually rigid, tied to the calendar rather than plant phenology, and without flexibility to adjust to unexpected weather conditions, and (2) the stocking rate for the comparison is set too low to allow forage

availability to be an effective limiting factor on vegetation production, and thus weather and the soil moisture regime obscure the treatment effects.

3. It is impractical to impose rigid regulations on an inherently flexible biological system.

4. Provided grazing systems are designed to conform to the ecological characteristics of the site, are implemented to increase harvestable forage, and are operated with the flexibility necessary in a ranching enterprise, there is no ecological reason rotational grazing systems should not be beneficial to the vegetation.

5. Range condition classification based on ecological climax is unrelated to suitability for livestock grazing and long-term carrying capacity on most western public land. Land management practices should define range condition and trend in terms of management goals rather than solely in reference to a presumed climax.

6. In most shrub-grass ranges of the West, reduction of livestock numbers will do little to "improve" the ecological condition or vegetational composition of the plant community. Rangeland deterioration and rangeland improvement often follow independent and even unrelated pathways. The sequence of vegetational change due to deterioration is not the reverse of vegetational change resulting from secondary succession. Most current management practices are based on information derived from observations of range deterioration, not direct study of the processes of range recovery.

7. Grazing by large herbivores often is of little importance in the process of vegetation change, unless grazing is so excessive that the grazed plants cannot restore themselves.

Watershed Characteristics

1. Grazing removes vegetational cover and causes trampling disturbances. If grazing exceeds the moderate level for periods of years, the results are as follows: (1) increased impact of raindrops on the soil, (2) decreased soil organic matter and soil aggregates, (3) increased surface vesicular crusts, and (4) decreased infiltration rates and increased soil movement.

2. Research has tended to evaluate livestock grazing impacts on watersheds after treatments have been in effect for 10-20 years. Most often, the watershed responses to various intensities and durations of grazing have been compared to those in a similar nongrazed area. Differences between light and moderate grazing are very small. On certain sites, there may be no significant differences among no grazing, light grazing, and moderate grazing. It has been abundantly demonstrated that abusive grazing imposes adverse impacts on the watershed. Land managers must not allow abusive grazing.

3. Few studies have evaluated watershed responses to specialized grazing systems or proper grazing intensity and animal management. Hydrologic measurements have often been confounded by range

improvement activities, past grazing practices, and climatic variations.

4. Outside of riparian zones, bacteria or nutrient pollutants do not seem to be a problem of normally grazed watersheds.

5. In rest-rotation grazing systems, damage may occur in pastures that annually sustain high concentrations of livestock. Each year, at least one pasture will sustain grazing utilization up to 80 percent, and such grazing decreases the potential rate at which rain or snowmelt can infiltrate into the soil and may increase sheet and rill erosion and reduce water quality.

Wetlands and Riparian Habitat

1. Grazing in wet areas affects wildlife by altering plant communities. Changing the structure of riparian zone vegetation from herbaceous to woody or woody to herbaceous will alter bird community composition according to nesting or feeding requirements. The same is true for other wildlife species.

2. Heavy or abusive grazing has adverse effects on breeding, nesting, and brood rearing of waterfowl. Mortality of young is also high because reduced herbaceous cover exposes them to predators.

3. Small mammal diversity increases directly with increasing levels of grazing up to a point.

4. Riparian zones are attractive to large domestic and wild ungulates, and even under moderate grazing of adjacent upland these zones are usually abusively grazed. Research has not adequately addressed development of methods for reducing this abusive grazing. Data from fenced versus unfenced areas and in aquatic zones show remarkable recovery from abusive grazing in 4-7 years.

5. A properly designed rotation grazing system appears to have possibilities for reducing grazing pressure on riparian zones. The riparian zone would need to be included in at least two of the pastures in the rotation scheme to achieve optimum response from rest.

6. A four-step planning process for grazing riparian zones should be established. The steps are as follows: (1) Determine the suitability of the affected habitat types for livestock grazing. (2) Determine the species and class of livestock best suited to the area. There is increasing evidence, for example, that herded sheep are much less detrimental to riparian zones than are traditionally managed cattle. (3) Determine the best grazing strategy that will maintain the wet zones, keeping in mind the objective of multiple-use management. (4) Apply the proper grazing intensity in keeping with animal distribution patterns.

Faunal Composition and Productivity

1. From an ecological perspective, there are three elements of importance to wildlife: species diversity, species function, and

animal numbers. When livestock management creates uniformity in the vegetation, it threatens those three elements.

2. Diversity is perhaps the most important of the three elements. It is the shock absorber for any catastrophe in the ecosystem, and it is an index to the general diversity of the system.

3. Grazing management should not cause a displacement of wildlife species into habitats less suited to their well-being. Species of livestock grazed, grazing intensity, and livestock management, including any specialized rotational grazing system, should be carefully considered with respect to their predicted impact on all wildlife.

4. Management goals should not stress absolute numbers in a wildlife population. It is more important to manage for diversity in species and species function.

5. Livestock and wild animals compete to a much greater extent at stocking levels that are excessive for one or the other or both. A high-priority objective of range management is to balance the demand of both livestock and wildlife for the finite forage supply. Livestock are thought to be better able to adjust their diets without detrimentally affecting their nutrition than wildlife; therefore when vegetation composition is altered through grazing, nutrition of competing wild animals declines in comparison with that of the more flexible domestic animals.

6. Rotation grazing schemes have been cited as being beneficial for certain wildlife species, such as the sandhill crane (Grus Canadensis), which prefers the higher insect density in grazed areas, and deer (Odocoileus), which are attracted to the recently grazed pasture because of the succulent regrowth.

Livestock

1. BLM should maintain as much flexibility as possible to use certain ranges, especially crested wheatgrass seedings, predominantly for livestock production purposes.

2. The livestock permittee should be assisted in animal management practices that will increase return per head. In general, BLM personnel are not well enough trained or experienced enough to provide such help. Public relations could be much improved if the attitude could be dispelled that the BLM range manager is an adversary.

3. There are critical periods for animal nutrition in the livestock production cycle. These should be taken into account in using specialized grazing systems or other management measures that put stress on livestock.

4. A reduction of permitted AUMs of grazing does not necessarily mean the permittee will suffer a comparable loss in net return. Improved application of animal husbandry practices can increase calf crop and weaning weight so that per-head yield is substantially increased. The manager should help the permittee apply these practices.

5. Current literature does not provide strong evidence that specialized rotational grazing systems dependably improve livestock production over systems of continuous grazing.

6. Data, though limited, tend to support the conventional logic that rangeland in high ecological condition (excellent to good) yields more animal products than rangeland in low ecological condition (fair to poor).

7. When stocking density is high, as in the Hormay-type rest-rotation system, animal performance will suffer. Rotation systems that spread the animals over a larger portion, say, three fourths, of the total area will produce animal gains nearer to those expected for continuous grazing.

8. Rotational grazing greatly complicates the forage supply-demand situation for livestock. Availability of forage fluctuates greatly unless the rotational grazing scheme is carefully designed to reduce that problem.

9. Too little attention is given to animal behavior in management of rangeland. This is especially true in specialized grazing systems, which can impose a grazing schedule that is radically different from the one the livestock have been accustomed to. The animal response is certain to lower short-term productivity.

10. The grazing system must deal adequately with environmental diversity such as variable forage supply, weather fluctuation, and the inevitable drought. The aim for grazing systems from the livestock perspective is a sustained and dependable forage supply.

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Chapter 4

MANIPULATIVE RANGE IMPROVEMENTS

INTRODUCTION

Largely because of past federal policies, grazing practices, and the climate, most western public rangeland is in a degraded condition. Professional opinion remains divided on whether range condition has improved or deteriorated over the last 50 years; however, there is a consensus that vast areas need immediate attention. Some rangeland is dominated by woody vegetation and undesirable species of annual grasses rather than the perennial grasses and forbs preferred for livestock grazing. However, because the woody plants are long-lived, manipulation of grazing intensity (or cessation of grazing) alone will not restore the rangeland. To increase livestock production on this rangeland, it may be necessary to manipulate the present vegetation by mechanical, chemical, or biological means.

Each manager determines the desired level of productivity of the rangeland on the basis of economic, political, and social factors and the availability of technology. Drastic manipulations of range ecosystems are sometimes required because of invasion by unwanted plants, severe droughts, past abuses by grazing animals, or the desire by the operator to change botanical composition, or productivity, on all or part of the range unit. Such manipulations require the application of many principles inherent in the relationships among climate, soils, plants, and animals. Without proper consideration of these environmental parameters the practices may not produce the desired results. Although the relative costs of these practices are high, the potential benefits may also be great. Control of unwanted plants, revegetation, and/or fertilization can increase forage production 100-1000 percent within 1-3 years. If these risky, costly practices are used, only superior management will reduce the probability of failure and heavy financial losses. To implement revegetation, the following questions should be asked: (1) What is the potential for this site? (2) Are there plant species that may be more productive or better able to meet a particular requirement than the plants growing there now?

Some native plants are poorly adapted for grazing use by animals or for recreational use. In certain areas the vegetation may be manipulated by the introduction of exotic plant species that are superior to native species. In the 1930s, for example, crested

wheatgrass (Agropyron desertorum) was introduced to enhance forage in the western areas of Canada and the United States.

Few, if any, managers use only principles that involve intensive practices on a unit of rangeland. Rather, practices employing both extensive (programs whereby broader ecological rather than agronomic goals are emphasized) and intensive (programs predominately aimed to increase forage yield per unit area) principles are used. For increased plant production and soil protection, each unit must be managed to maintain or improve the basic resources. In the Northern Great Plains of Canada and the United States, this may mean seeding part of the range unit with Russian wildrye (Elymus junceus) and crested wheatgrass and using nitrogen fertilizer on both native and introduced species. In portions of the Northern Great Plains, the best practices may include judicious burning of parts of the native rangeland and plowing up the native sod on some of the better sites and seeding wheat (Triticum aestivum) for forage, or for forage and grain. On the semiarid Southern Great Plains and associated grasslands of Mexico and the United States, a useful strategy may include seeding weeping lovegrass (Eragrostis curvula), sideoats grama (Bouteloua curtipendula), wheat, and sudangrass (Sorghum sudanensis). In the arid portions of the southwestern United States and northern Mexico, range productivity could be greatly increased by control of mesquite (Prosopis juliflora) and tarbush (Flourensia cernua) and seeding with Lehmann and Boer lovegrass (E. lehmanniana and E. chloromelas) and fourwing saltbush (Atriplex canescens). On rangeland infested with big sagebrush (Artemisia tridentata), control of the sagebrush and seeding with crested wheatgrass often results in much greater forage productivity and soil stability than would otherwise be obtained. In some instances, composition of plant species may be manipulated to improve wildlife habitat and at the same time maintain or improve livestock production.

The use of various practices is changing with time as dictated by economic, political, and/or social conditions, or as improved technology becomes available. It is important that the range resource is maintained or improved as it is managed to meet multiple objectives. Land managers, and others working with land managers, must be flexible and innovative in their planning. The potential for each range site must be determined before implementation of a treatment program. What will work well on one range unit may not work well on another.

EVOLUTION AND ECOLOGY OF RANGE PLANTS

Factors responsible for vegetation changes include (1) climate, (2) grazing by wild or domestic herbivores, (3) fire, (4) plant adaptations, and (5) governmental policies.

In some areas, notably the Great Plains, the evolution of rangeland plant communities was influenced by both climate and native herbivores. In other areas, such as the arid portions of the

Southwest and Great Basin, native herbivores had less of an effect, and climate was the most important factor affecting the evolution of vegetation. However, the heavy grazing by domestic livestock during the nineteenth and first third of the twentieth centuries may have exerted pressures with which plant communities were unable to cope. In addition to applying grazing pressure, livestock also disseminate propagules of undesirable plants. Selective grazing may weaken some desirable plants and allow more room for less desirable plants. Decreases in protective plant cover may increase soil erosion. Protection from grazing, however, would be useless in many areas because unwanted, primarily woody, species are established and compete more successfully for the limited resources needed for plant health.

Fire can play a major role in vegetation composition. However, today's arid rangeland generally does not have sufficient fuel to carry a major fire. Furthermore, the distribution of fuel can be patchy, and this prevents a fire from uniformly influencing all vegetation. There is also considerable difference in the effect of fire on various species of range plants.

Many of the plant species in the western United States evolved under conditions that are different from those now extant. Therefore some of these plants are not well adapted to higher grazing pressures, and, in some instances, suppression of fire.

Governmental policies are indirectly responsible for vegetation changes because they affect management and use of rangeland. Prior to the 1930s, public rangeland policy was largely nonexistent. Only recently did the policy of management for grazing dominance give way to active management for multiple uses. This topic is addressed fully in the NRC Workshop VI on Political and Legal Aspects of Range Management (NRC 1981).

SAGEBRUSH AND SALT DESERT ECOSYSTEMS

The sagebrush-grass and salt desert shrub ranges of the intermountain area of western North America consist of a complex array of plant communities. During the nineteenth century, the sagebrush-grass ranges were altered by the agriculture of the settlers. This ecosystem was not adapted to concentrations of large herbivores (Young et al. 1981). The introduction of livestock and exotic plants along with the resistance of shrubs to grazing led to a rapid increase of shrubby vegetation and some herbaceous plants. A grazing pattern was established that used high-elevation ranges in the summer and sagebrush-grass and salt desert shrub ranges in the fall, winter, and spring.

Weak seedling competition, combined with limited seed production and seed dormancy, makes it difficult to revegetate sagebrush-grass ranges with native plants. However, in the late 1930s it was found that crested wheatgrass was well adapted to these ranges and could be successfully seeded to provide livestock forage. After World War II,

it was recognized that 2,4-D would control sagebrush species and thereby lead to increased stands of residual perennial grasses (Young et al. 1981). Picloram is also useful for controlling associated woody plants. Paraquat was used to control cheatgrass (Bromus tectorum) on sites to be seeded because it is deactivated when it strikes the soil. Virtually any range improvement practice requires deferment of grazing for optimum stands of desirable vegetation. Practically no range improvement techniques exist for salt desert ranges.

PINYON-JUNIPER ECOSYSTEMS

Six species each of pinyon pine and juniper trees dominate woodlands occupying approximately 325,000 km^2 (125,482 mi^2) in semiarid portions of the western United States. The extent of these ecosystems is much greater now than when settlers first came to the western United States because livestock grazing has reduced competition from herbaceous plants, and fires have not occurred frequently enough to kill the young trees (West 1981). Reduction of livestock numbers will not reverse or stop these successional changes. The successional pattern for most sites in pinyon-juniper ecosystems indicates that the climatic climax is dominated by pinyon pines and junipers. An active treatment program would be required to return these ecosystems to a grassland-tree savannah. Land managers conducted programs of tree control from the 1940s through the early 1960s to increase herbage production. Recent legislation and increased costs of manipulation have reduced these activities and forced closer scrutiny of the ecological impacts associated with treatment programs (West 1981). Immediate action is required to reduce soil erosion and prevent loss of site potential in these ecosystems.

SOUTHWESTERN DESERT ECOSYSTEMS

The land resources of the Southwest include plateaus, plains, basins, and isolated mountain ranges. The three ecosystems discussed are the southwestern shrub-steppe, desert shrub, and desert grasslands of Arizona, New Mexico, and Texas. The average annual precipitation over most of this area ranges from 200 to 300 mm (7.9-11.8 in.). The growing season precipitation occurs during the summer, and the spring period is normally very dry and occasionally windy. The three major arid ecosystems in the Southwest occupy a total of 36.2 million ha (89 million acres) and currently have a stocking level of nearly 6 million animal unit months (AUMs). If the potential of these ecosystems could be realized, present stocking rates could increase dramatically (Herbel 1981).

Species composition of many plant communities has been altered. Woody plants, such as mesquite, creosotebush (Larrea tridentata), and

tarbush, along with certain other plant species, cannot be controlled by improved grazing practices alone (Herbel 1981). Mesquite is considered detrimental throughout the semidesert range area. Mesquite invasion is associated with decreased density and herbage yield of grasses and increased sheet and gully erosion. Creosotebush has no grazing value, and forage production in moderate to dense stands of creosotebush is negligible. Tarbush is a deciduous plant that grows primarily on medium to heavy textured soils and its presence results in a dramatic decrease in the production of herbaceous plants.

ECONOMIC EVALUATION OF RANGE IMPROVEMENT PRACTICES

A range improvement project must have a specific goal, otherwise progress will be difficult to measure. There are several criteria for making decisions on range improvements: (1) least-cost approach (the cheapest way of achieving a range improvement goal); (2) worst-first approach (improve the site in poorest condition regardless of cost); and (3) net benefit approach (choosing the treatment that has the highest net benefits) (Nielsen 1981, Gray 1981). For optimum allocation of limited funds, the net benefit criterion should be used at all levels of decision making. This criterion places the emphasis on sites and practices with the greatest potential for increases in net benefits (benefits minus costs). Each range site should be classified as to which range improvement, if any, should be made and what the potential of the site is for various uses. Some of the costs of range improvements to consider are (1) land treatment costs; (2) structural developments (e.g., fences, water developments); (3) nonuse of grazing animals; and (4) administrative costs (Nielsen 1981). Some of the benefits are (1) increased livestock numbers; (2) increased livestock performance; and (3) improved multiple-use options. Three criteria have been used to determine the economic feasibility of range improvement alternatives and to rank them: (1) internal rate of return; (2) current net worth; and (3) benefit-cost ratio. (These criteria are discussed fully in Chapter 5.)

ROLE OF LAND TREATMENTS ON PUBLIC AND PRIVATE LANDS

Economically feasible land treatments are easier to implement on privately owned land, where the major limitation is the economic status of the landowner. On private land, the treatment is most often applied for a single use or a few uses. On public land, treatments can be made only after extensive public involvement, and they are more likely to be applied for several uses. Treatment of public and private lands must be coordinated because of the interdependence of the properties. Although many treatments are available, none offers a panacea. Each technique is site specific and will succeed only if the needs of the site are known (Box 1981).

RECOMMENDATIONS

General

1. Range management strategies should be based on an understanding of the biological requirements and limitations of range ecosystems.

2. The selective pressures of arid and semiarid grazing lands affect the success of range improvement practices and the probable costs of the different managerial approaches. Approaches that take biological selective history into account are most likely to succeed.

3. Improvement practices that use ecological principles should be recommended on a site-specific basis.

4. Proper management of range improvement practices is critical if they are to be successful.

5. Managers should be realistic in their expectations and approach to land treatment. The plan should establish a precise and measurable goal and recommend methods that have a high probability for success.

6. Two or more technologies, e.g., mechanical brush control followed by fire and improved grazing management, should be used if they are superior to a single treatment.

7. Treatments on private and public lands should be coordinated to enhance their overall value. Modifications of vegetation on public lands to increase grazing capacity must take into account the requirements of these animals in total rather than only for the time they are on public lands.

8. Managers should consider the use of domestic livestock and wildlife species in various combinations to optimize forage utilization.

9. All planning for range improvements and subsequent management should be integrated, and total benefits and costs--to wildlife, livestock, watersheds, ecological integrity, and recreation--should be assessed.

10. Positive steps should be taken to reduce stands of unwanted woody plants on rangeland. Reducing livestock numbers, or removing them from a unit of rangeland, is not a solution.

Evolution and Ecology of Range Plants

1. Managers should recognize that different plant and animal species may respond quite differently to the same managerial approach.

2. Important traits of plant species proposed for introduction to a region (annual-perennial habit, carbon assimilation pathway, sod formation, etc.) should be compared with those of the native dominant species. Although it is not necessary to mimic current dominant plants, there should be good reasons for introducing different plants.

3. Managers should take into consideration plant production as well as the ease of plant establishment (particularly on harsh sites).

4. Use of chemical and mechanical methods for improving rangeland should be assessed not only with regard to immediate biological and economic impact, but also with regard to long-term biological effects.

5. More research is needed on the effect of environmental stress on individual plant responses/life cycles.

Sagebrush and Salt Desert Ecosystems

1. Treatment of sagebrush communities, when feasible, should include application of 2,4-D to reduce sagebrush when there is an adequate stand of residual grass plants. If the degraded sagebrush stand lacks sufficient perennial grasses, the improvement practice must include seeding.

2. If weedy annual grasses are not present, the shrubs in the sagebrush community can be controlled with 2,4-D and a mixture of desirable species seeded in the standing dead brush. If weedy annual grasses are present, some form of herbaceous weed control is necessary if seeding is desired.

3. The atrazine fallow method for herbaceous weed control in the sagebrush community can be vertically integrated with brush control to obtain total site conversion.

Pinyon-Juniper Ecosystems

1. Where feasible, the areas treated in the 1950s and 1960s should be re-treated where undesirable shrubs have returned to dominance.

2. Seeding of desirable forage plants onto burned sites should be done promptly. The opportunities provided by wildfires for revegetation and plant control should be acted upon more often, where needed.

3. Prescribed burning of pinyon-juniper should be used more often where tree stands are sparse and understory vegetation is adequate to carry fire and provide sources of propagules. This should be contemplated primarily for sites with less potential for tree growth, mainly the scattered juniper at the upper and lower boundaries of the woodland belt.

4. Additional herbicides should be evaluated for their efficacy in curtailing tree and shrub populations. Before herbicides or prescribed burning is used, the public should have an opportunity to harvest the wood products.

5. Tree harvesting should be integrated into plans to change the size and age class mosaic on entire watersheds. Small patches of trees should be marked for use as fence posts and fuel wood. Such revenues from tree utilization will help defray costs of other treatments. Over time the landscape would develop patches of different aged treatments and would be more aesthetically pleasing as well as have positive effects on watersheds and wildlife.

Southwestern Desert Ecosystems

1. Because of frequent and prolonged droughts, it is important to sustain a high level of flexibility in management and utilization of rangeland in the Southwest.

2. Control methods should be used on unwanted plants--improved grazing practices will not control woody plants such as mesquite and creosotebush. The proper method of plant control should be selected on the basis of site potential, the target species, and the degree of infestation.

3. Mesquite may be controlled by use of several chemical and mechanical methods. One of the methods used is aerial spraying with 2,4,5-T, 2,4,5-T+ dicamba, or 2,4,5-T+ picloram. Another promising method is the aerial application of tebuthiuron pellets. There is a substantial increase in plant growth with control of dense stands of mesquite on sandy soils.

4. Creosotebush and tarbush may be controlled with an aerial application of tebuthiuron pellets. Sites heavily infested with creosotebush and tarbush may be rootplowed and seeded where there is no residual stand of desirable plants. Tarbush may also be controlled by chaining or railing when the plants are dormant. The following species may be seeded on light- to medium-textured soils: Boer and Lehmann lovegrasses, black grama (*Bouteloua eriopoda*) and sideoats grama, yellow bluestem (*Bothriochola ischaemum*), blue panicgrass (*Panicum antidotale*), and fourwing saltbush. Plants adapted on medium- to heavy-textured soils are alkali sacaton (*Sporobolus airoides*), sacaton (*Sporobolus wrightii*), vine mesquitegrass (*Panicum obtusum*), blue panicgrass, yellow bluestem, and fourwing saltbush.

5. Practices such as seeding, control of rodents and rabbits, and fertilization should be used only on limited areas with special needs and with a high potential for production of forage.

6. To a great extent, riparian communities have been damaged irretrievably. They may be partially recovered by seeding willows (*Salix* spp.), cottonwoods (*Populus* spp.), blue paloverde (*Cercidium floridum*), and fourwing saltbush and big saltbush (*Atriplex lentiformis*). However, grazing will still need to be controlled.

7. Water-spreading schemes substantially increase forage production where sedimentation does not pose a serious problem. The watershed area above the water-spreading site should provide at least one flooding per year; however, this does not occur in the drier portions of the Southwest.

Economic Evaluation of Range Improvement Practices

1. Management decisions should take into account the uses of the land.

2. Land managers should be certain that the criterion used within the agency to allocate range development funds is the same one used by others to evaluate the success of the program.

3. Variance in yields, costs, and prices in range improvements is high and must be considered in the economic analysis. The simplest way to include risks may be to add a risk premium to the discount rate.

4. High interest rates diminish the value of benefits received in future years; therefore rapid net returns have a higher value than those in the distant future.

5. The net benefit principle should be used as an allocating criterion. This principle emphasizes the selection of sites and practices having the greatest potential for increasing the differences in per acre benefits and costs.

6. In allocating range resources among competing uses, the same type of economic analysis should be made for each use.

7. Policies on required nonuse should be biologically justified, since the managerial policy of nonuse has such a pronounced effect on the economic feasibility of improvement practices.

8. The government should reimburse livestock permittees for the unused portion of private investments in range developments on government land if and when a change in land use eliminates or seriously reduces grazing.

Role of Land Treatments on Public and Private Lands

1. Estimates of productive potential are essential to the design and implementation of land treatments, and these should be developed over two drought periods.

2. Range improvement practices should be monitored continually to assess their overall utility. The length and frequency of monitoring depend on the annual variability in precipitation.

3. The availability of propagules needed to revegetate rangeland should be determined, and more attention should be given to selecting genetically improved plants.

4. Renewable resource management in arid and semiarid areas depends both on ecological and on agronomic management. Ecological management procedures that will work on agronomically developed grazingland ecosystems are needed.

5. A careful evaluation of the relationship between plant and animal productivity is needed, and it needs to be compared to indices commonly used to depict range condition. A high ecological condition is not always the most productive.

6. The range site or habitat type is the basic unit for management of rangeland. These ecological response units must be identified clearly. It is impractical to research each range improvement practice on each type of unit. Thus response units must be placed on a continuum or otherwise aggregated so that results found in one unit may be extrapolated to others. Also, we must have information on the relationships among response units under various conditions that are managed as a unit.

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Chapter 5

APPLYING SOCIOECONOMIC TECHNIQUES TO RANGE MANAGEMENT DECISION MAKING

INTRODUCTION

The objective of the Workshop on Applying Socioeconomic Techniques to Range Management Decision Making was to stimulate review and discussion of promising socioeconomic analytical techniques that have been or might be applied to the management of public rangeland. The summary and the conclusions and recommendations that follow represent a distillation and interpretation of the most significant and useful points raised at this workshop.

ROLE OF ECONOMIC ANALYSIS

Economics deals with problems of efficiency and equity. Efficiency involves allocation of scarce resources among competing uses and time periods to produce the greatest quantity of net output (product) from a given amount of input (resources). Equity concerns the distribution of products among competing consumers and resource owners. Resource allocation affects both efficiency and equity, each of which contains elements of objective economics (what is) and subjective economics (what ought to be) (Gardner 1981, Bromley 1981).

It is a national ethos in the United States that efficient production is a desirable goal. Optimum resource allocation is necessary to achieve this goal, but federal land management equity goals often lead to inefficient resource allocation decisions. An example is the eligibility requirements for holding federal grazing permits. The requirements were adopted originally to achieve equity goals, but their retention presents a serious transfer restriction that precludes both competition among stockmen and ultimate use of forage by the most efficient ranchers.

Legislative mandates for multiple use are not only ambiguous as management criteria, they create barriers to achieving efficiency and equity in implementation (Gardner 1981). One equity problem is that some users of public rangeland (stockmen holding grazing permits) pay fees, while others (recreationists and watershed beneficiaries) do not.

Recent BLM memoranda outlining procedures to be used in ranking range allotment management plans are a definite improvement over

previous Bureau procedures, but they contain several analytical errors and inconsistencies that should be corrected (Gardner 1981).

There is need for more rigorous economic and social analysis within BLM. Bureau administrators must deal with extremely complex economic and social issues whose resolution will require the most competent and best-trained people available.

INVESTMENT CRITERIA

Federal land management agencies have traditionally used economic feasibility as a criterion in analyzing and choosing among public investments while retaining the power to base actual investment decisions on other than economic grounds. Federal managers have long tended to use economic analysis to justify a decision after it has already been made rather than to determine if it is economically feasible. Economic analysis should be undertaken early in the BLM planning process, well ahead of final decision and justification (Workman 1981).

Federal agency benefit-cost analysis is plagued with the problem of comparing market and nonmarket values. Alternative means of resolving this problem are the "cost-effectiveness" approach (an attempt to avoid comparison of market and nonmarket values) and the "search for values" approach (an attempt to assign derived values to nonmarket benefits and costs). Cost-effectiveness offers little help in answering practical questions of how best to allocate limited budgets and personnel among competing needs. The approach also makes it possible to justify any project economically. Thus cost-effectiveness should be used only when projects cannot be justified on economic grounds. Efforts to value nonmarket benefits should continue, and the resulting values should be used in decision-making activities, not merely for decision justification (Workman 1981).

Even when all benefits and costs are expressed in dollars, contradictory project selections are often made by the three standard investment criteria, i.e., benefit-cost ratio, internal rate of return, and current net worth. The contradiction problem can be avoided by normalizing alternative projects for differences in life expectancy and required initial investment or, more simply, by using current net worth as the criterion for selecting among alternative investments (Workman 1981, Bartlett 1981).

The management units analyzed in BLM benefit-cost analysis should correspond to the management units employed in BLM budgeting decisions. Thus the focus of analysis should be shifted from allotment management plans (AMPs) to resource management plans (RMPs). The shift would make the planning and program budgeting processes more consistent with decision making involving the production of two or more products.

Where there are interactions among individual range improvement projects (e.g., fencing, water, development, or revegetative efforts), project combinations should be analyzed as a package and not as individual projects.

It is doubtful that BLM decision making can ever be based on a single criterion such as economic efficiency or environmental quality. This fact should be made explicit, and BLM should retain a system of multiple criteria as its basis for decision making.

MEASURING ECONOMIC IMPACTS OF AGENCY PROGRAMS ON USERS AND LOCAL COMMUNITIES

Impact analysis involves the economic equity problem. It is conducted from a regional perspective as contrasted with benefit-cost analysis, which concerns the problem of economic efficiency from a national perspective. Analyses of distributional impacts begin with the following questions: (1) What impact is to be measured? (2) What is the likely magnitude of the impact? (3) When will the impacts occur? (4) Who will be affected (Godfrey 1981)?

Effects of federal agency programs fall into two general categories: microeconomic effects (impacts on individual users) and macroeconomic effects (impacts on economic regions) (Godfrey 1981, Olson 1981). Microeconomic impacts, such as changes in the income of users of public land, are commonly estimated by budgeting and linear programming techniques. Both approaches provide accurate measurements of the ability of users to adjust income in response to changes in agency programs, but neither provides estimates of the willingness of users to respond. For this reason, private market prices for comparable products provide the best measure of impact on users. Care must be taken that the products (such as range forage) are truly comparable by adjusting for differences in services provided (e.g., fence maintenance, salting) and season of availability (e.g., spring versus fall forage).

BLM programs affect the wealth of users as well as their incomes, and the two effects are closely related (Godfrey 1981). For example, low user fees (an income impact) are capitalized into grazing permit values held by ranchers or into higher values of private land owned by hunting guides and outfitters (wealth impacts).

Input/output (I/O) analysis is generally considered the most accurate method available for estimating regional macroeconomic impacts. Development of I/O models, however, is an expensive and time-consuming process. While economic base models are less expensive than I/O models, they are a poor substitute in terms of accuracy. The Dyram model currently used by BLM may be the best substitute available in view of the Bureau's budget and time constraints (Godfrey 1981).

In general, the tools available for evaluating impacts of changes in federal policy on public land users are capable of producing stronger analyses than those currently being performed by BLM. Bureau impact analyses are often conducted in insufficient time by poorly trained and inexperienced people. Recent BLM instruction memoranda are more defensible with respect to procedures advocated for measuring livestock grazing impacts than those outlined for other uses (e.g., recreation, wild horses, or watersheds).

NONMARKET VALUATION

Both legislative mandate and Department-OMB budget review policy suggest that BLM will have to undertake rigorous economic efficiency analysis, which includes consideration of nonmarket outputs. Procedures acceptable to policy makers and their staffs for assigning value indices are necessary if nonmarket output portions of the total BLM program are to receive adequate recognition (Dyer 1981).

There is reason to be both optimistic and cautious about the state of the art in valuation of nonmarket outputs. Some economists argue that nonmarket value indices are sufficiently precise to be useful in benefit-cost analysis. A significant number of other economists (particularly those in agency staff positions) view nonmarket valuation as a useless exercise that produces nothing but additional confusion. These mixed messages leave analysts within public land management agencies in a difficult position. To ignore nonmarket outputs excludes them from economic analysis. On the other hand, to proceed with computation of value indices without an adequate basis for evaluation may invite ridicule from parts of the economics and decision-making communities. In the current environment it seems essential to value nonmarket outputs, but it is not at all clear how seriously these values will influence actual resource allocation (Dyer 1981).

A near consensus exists in the literature that the willingness-to-pay procedure is the most appropriate conceptual framework available for valuation of nonmarket outputs. This in turn suggests that valuation requires estimation of demand schedules.

Useful and reliable analytical techniques are available for valuation of many nonmarket outputs (e.g., wildlife, recreation, water, and forage) (Dyer 1981, Howitt 1981). However, values for some nonmarket products (e.g., aesthetics, endangered species, and Indian burial grounds) cannot now or perhaps ever can be expressed in monetary terms. The fact that some products do not lend themselves to strict economic analysis does not mean that such products are any less important than those that can be expressed in monetary terms. The problem is how to include them in a decision analysis where they can be adequately evaluated and compared with products that can be evaluated monetarily.

ASSESSMENT OF SOCIAL IMPACT

In most agencies, social impact assessments (SIAs) are carried out because the National Environmental Policy Act of 1969 (NEPA) and related administrative guidelines require consideration of the effects of the social as well as the natural environment. A social impact assessment consists of the identification, analysis, and evaluation of social impacts resulting from a particular event. A social impact is a significant improvement or deterioration in people's well-being or a significant change in an aspect of community concern (Dietz 1981).

Ideally, SIAs should be used as tools to allow both BLM personnel and citizens to become better informed about the broad range of social impacts that result from range management programs. Unfortunately, as currently practiced, many SIAs are not useful to resource managers because they are prepared at the end of the planning process, long after critical decisions have been made, and because they do not adequately focus on those social impacts that are politically important (Dietz 1981).

SIAs should serve as tools for integrating people's values with technical information as part of the decision-making process. Simple SIAs can be used early in the planning process to sketch out alternative strategies and provide the manager with an understanding of trade-offs involved in choosing among alternative plans (Dietz 1981).

SIA methods to be used by BLM must be (1) frugal, (2) flexible, (3) integrative, and (4) explicit about impacts. SIA methods must be frugal in their use of time, money, and technical expertise. To be most useful to BLM, SIA methods should be general and able to accommodate a variety of plans and associated impacts. Since both subjective and objective impacts must be considered, an effective SIA technique should integrate them from the start of the assessment process. Techniques to be used by BLM must first emphasize careful impact identification. This would facilitate later improvements in analysis and evaluation (Dietz 1981). An example of where such approaches to an SIA have been particularly successful is the Berger inquiry into the proposed Canadian MacKenzie Valley Pipeline (Gamble 1978).

The most important step in improving BLM's SIA practices is to integrate SIAs into an early point in the planning process where the assessment and resulting public discussion can actually influence management decisions. SIAs should be used in describing and understanding alternative plans. The use of panels of experts has been a successful technique with other planning agencies and should prove useful to BLM.

If BLM wants to improve its SIA practices, it should begin to monitor social consequences of range management plans already in effect. Careful postproject impact assessments should be developed to improve knowledge of the consequences of BLM range management programs.

In general, BLM is more in need of a sensitivity to and awareness of the broad social impacts of its programs than of more data on social impacts of small disaggregated activities (Johnson 1981).

SOCIOLOGICAL TECHNIQUES

As a planning tool, public involvement provides an initial assessment of the thinking of a client population about various management alternatives. It then considers the expressed public input in the decision-making process. Sociologists working with BLM have used hearings, panels of experts, and face-to-face interviews as ways of obtaining public input (Burdge 1981, Brodnick 1981).

With the passage of NEPA, BLM began to experience important shifts in its political environment that it believed could be influenced if more sociologists were hired. The vehicle by which these people-oriented employees were to stabilize the increasingly complex political environment was public involvement, which was seized upon uncritically by both academics and agency officials as the key to politically acceptable decision making. Analysts often have been less than candid about public involvement limitations, have promoted public involvement as the key to better decision making, and have failed to discuss the costs of public involvement in terms of mobilizing and organizing dissent and the introduction of new decision variables. Not surprisingly, public involvement has failed to be a panacea. For reasons that are less clear, agency social analysts have been surprisingly reluctant to scale their public involvement programs to the more realistic intent of the Federal Land Policy and Management Act of 1976 (FLPMA), which explicitly encourages targeting representatives from state and local governments for involvement in planning efforts.

Instead of placing undue emphasis on public involvement efforts, BLM should emphasize the development of cooperative, stable interactions with other levels of government. A candid assessment should be made of the potential for social analysis in BLM planning, and in-service training programs should be developed to teach topics such as understanding social group processes and handling conflict in a group setting. Some of BLM's efforts in this area should be devoted to activities that promote the anticipation of future problems. Major steps in this direction can be taken by structuring opportunities for BLM managers to share their experiences with other agency personnel and by improving the existing skills of its managers.

MITIGATING ECONOMIC IMPACTS OF AGENCY PROGRAMS

Changes in BLM management policies affect various public land users and local communities, both positively and negatively. The process of minimizing adverse impacts of policy changes is termed "mitigation."

Virtually all policies involve trade-offs. Only rarely will a government action designed to help one group of people not simultaneously adversely affect another group. Thus, if policy implementation is to not make some people worse off than they were originally, the losses of the losers must be mitigated or compensated. The Kaldor-Hicks compensation test states that a necessary condition for recommending a policy change is that the benefit-cost analysis must reveal that the gainers from the change could compensate the losers and still be better off.

One such policy change is the reduction of livestock forage allowed to be harvested on BLM grazing allotments. The most obvious impact falls on the persons holding grazing permits. However, research in Arizona by Martin et al. (1978) shows that while lost

rancher income due to permit reductions amounted to $72 per animal unit year (AUY) of forage lost, consumer surplus values for hunters and beef consumers are far greater ($420 and $860 per AUY, respectively). Aggregate value of one AUY of forage to beef consumers, local agriculturally based communities, hunters, and ranchers was $1358. Thus range improvement investments would be socially desirable if required capital did not exceed $1358 per AUY gained or retained. Annual per capita values of programs to maintain or increase range forage production were $4.50 for beef consumers, $100 for hunters or members of the local community, and several thousand dollars for grazing permittees.

On a per AUY basis, both hunters and beef consumers in general have much more economic interest in avoiding federal range deterioration than does the rancher. Where livestock grazing reductions are needed to improve range condition, mitigation is simply a question of recognition of property rights. If hunters as a group believe ranchers have a right to their current levels of public land grazing, gains by hunters could easily allow them to pay ranchers to reduce their herds. Thus a possible mitigation approach is as follows: Assuming that ranchers have a right to their current levels of public forage use, that local communities have a right to the current level of economic support provided by ranchers, and that reductions in grazing allotments will eventually increase usable forage, compensation of ranchers for livestock grazing reductions would be an equitable solution. The general public--beef consumers and wildlife enthusiasts--could simply buy the necessary portion of a rancher's allotment at prevailing prices. Later, when the range has improved sufficiently to allow expansion of grazing permits, ranchers could buy back their allotments at the current market price (Martin 1981).

Such a program would require new legislation, but if BLM must mitigate negative impacts of its program, this proposal should be seriously considered.

CONCLUSIONS AND RECOMMENDATIONS

Role of Economic Analysis

1. Multiple-use management should be based on solid empirical analyses that attempt to quantify costs and benefits of the products produced on public lands. Whenever possible, environmental concerns should be directly incorporated into benefit-cost analysis rather than used as a separate ranking device for project selections.
2. More Bureau time and money should be devoted to economic analysis.
3. Elimination of grazing permit eligibility requirements (prior use, commensurability, ownership of land and water) should be considered. Such elimination would allow for free transfer of grazing permits among ranchers at market-dictated prices.

4. If grazing permits are permanently reduced, permittees should be compensated proportionately for their interest in range improvements just as they are for permit cancellations.

5. Incentives for private investment in public range improvement should be created by devising a system for evaluating changes in grazing capacity that is credible to ranchers, including a guarantee that increased forage will be made available to participating permittees.

6. Benefit-cost analysis of range improvements should be based on all costs and benefits, both private and government.

Investment Criteria

1. Economic analysis should be implemented early in the BLM planning process, well ahead of any final management decision.

2. Attempts to measure nonmarket benefits and costs associated with range improvements should continue. These values are already assigned (at least in the mind of the manager), and the more explicit this process, the less likely that the final management decison will be viewed as arbitrary by various BLM constituencies or by the Office of Management and Budget.

3. Estimated nonmarket prices should be used as inputs to the decision-making process and not merely contrived to justify decisions already made. If the decision-making process is explicit, justification of the resulting decision will be easier.

4. In choosing between alternatives, current net worth should be used as the exclusive criterion.

5. In selecting an optimum combination of projects, the following procedure should be used:
   a. Rank projects by benefit-cost ratio.
   b. Select best projects first until available capital is exhausted.
   c. Perform current net worth side calculations to verify the accuracy of the selected project combination.

6. The management units analyzed in BLM benefit-cost analysis should correspond to the management units employed in BLM budgeting decisions. Thus the focus of analysis should be on RMPs rather than AMPs.

7. The analytical procedures outlined in BLM Instruction Memoranda 80-57 and 81-296 should be carefully reviewed. Double counting may occur in the allotment management plan economic analysis (80-57), and noncommensurate ordinal numbers are added in 81-296.

Measuring Economic Impacts

1. The procedures outlined in recent BLM instruction memoranda (80-57 and 81-296) can provide adequate assessments of BLM policy impacts on individual users and local communities.

2. The outlined procedures should be used only by well-trained and experienced analysts. BLM should either employ economists with agricultural training or provide such training in-service.

3. An in-service review process should be established to help determine the applicability and weaknesses of procedures outlined in BLM memoranda, especially as applied to income and employment impacts associated with recreationists.

4. More emphasis should be placed on evaluating the impacts of alternative BLM actions on income and wealth distribution. Such evaluations should determine who benefits from and who pays for changes in the use of public lands. BLM management decisions should take these impacts into account.

5. The BLM and Forest Service cooperative agreement with the USDA Economics, Statistics, and Cooperatives Service is a significant step forward in obtaining reliable ranch budget data. Even greater cooperation with other federal agencies, particularly the Cooperative Extension and the Soil Conservation Service, could provide technical help when private land use is affected by federal management decisions.

6. BLM administrators at the national level need to aggregate the impacts of the numerous small decisions made at the district level.

Nonmarket Valuation

1. BLM should develop regional demand estimates for recreation, wildlife, and livestock forage. These analyses might be accomplished most efficiently by cooperation with USDA analysts.

2. For valuation of recreation experiences, travel cost models are preferred for development of empirical demand schedules because they reflect what people really do, not what they say they will do. In cases where users are clustered around the site in question and for dispersed recreation such as primitive hiking, the bidding-game-survey method may be more appropriate.

3. When a recreation experience is tied to a wildlife population (i.e., hunting), valuation should focus on the recreation experience and the analysis should proceed as described in point 2 above. When the animals themselves are the target of the valuation, either of the following approaches can be used: (1) wildlife are viewed as an input to the production of wildlife-related recreation experiences, and traditional "value of the marginal product" (VMP) logic is used to estimate willingness-to-pay indices, or (2) bidding game techniques are employed to estimate the value of the animals.

4. For livestock forage valuation, where comparable private lease rates are available and proposed forage changes represent only a small percentage of total usable forage, private lease rates should be used as an approximation of willingness-to-pay for incremental units of BLM forage. Where comparable private lease rates are not available for valuation of small forage changes, the ranch budget approach should be used. In cases where proposed forage changes are

large in relation to total usable forage, the market demand schedule should be estimated by either willingness-to-pay surveys or optimization analyses of sample ranches.

5. For water valuation, application of demand schedule and willingness-to-pay analyses is extremely difficult. Fortunately, estimates provided by Bureau of Reclamation and Corps of Engineers economic analyses should be suitable for BLM purposes. In many cases, Resource Planning Act output values would be adequate.

6. Shadow prices developed with linear programming and other optimization techniques without reference to demand will not solve the valuation problem. Similarly, goal programming, while a useful management analysis technique, is of no help in valuation.

7. Some important outputs of the public lands are not amenable to monetary valuation. This fact must be recognized, and such outputs should not be discriminated against in management decisions.

Social Impact Assessment

1. As currently practiced, BLM Social Impact Analysis does not even adequately identify impacts. Before attempting improvements in SIA analysis and evaluation, BLM should strengthen the impact identification process.

2. It should be remembered that the public land users' perceptions of reality are just as important as reality itself in influencing their reactions to federal policy.

3. Sensitivity of BLM personnel to social impacts might be improved by more discussion among employees who have dealt with these impacts on a day-to-day basis. BLM should consider developing a brief manual based on the successful experiences of their managers. Instead of a longer "grocery list" of possible analytical techniques, BLM analysts need guidance as to how to think through social implications of their programs.

4. BLM should begin to monitor economic and social consequences of range management plans that have already been implemented. Postproject impact assessments should be performed to provide a self-correcting aspect to the assessment techniques.

5. The issues with which social analysts are trained to deal are extremely important in BLM planning. However, their skills are currently often misapplied and therefore undervalued. Sensing this, social analysts in BLM have become frustrated and have tended to oversell their skills, making a bad situation even worse.

6. Social impacts are often trivialized when technically trained BLM analysts try to measure such impacts in scientific quantitative units. There is a need to integrate concepts such as community cohesion into the planning process, but these important concepts tend to be excised in favor of less useful but more quantitative measures.

Sociological Techniques

1. A candid assessment should be made of the potential for social analysis in BLM planning. Social impact assessment should be focused on large, important, discernible impacts such as those resulting from major land reallocations rather than on minute activities.
2. As specified in FLPMA, BLM should attempt to obtain inputs into their planning efforts from other agencies--local, state, and federal--rather than placing primary emphasis on public involvement.
3. BLM should develop in-service training programs to teach topics such as understanding social group pressures and handling conflict in a group setting.

Mitigating Economic Impacts

1. A collaborative effort of economists and range scientists is badly needed to determine what production function data are required and how to best proceed to obtain reliable data.
2. Reductions in permitted livestock grazing constitute a wealth transfer from the grazing permittee (who pays fees for the privilege) to groups who pay no fees but who claim to place a high value on amenities.
3. Since market prices minimize the amount of information required to make optimum decisions, BLM should place more reliance on the free market as an indicator of needs for and values of resources and products.

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